LUNAR LANDING

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.

A new era of NASA space exploration began on July 20, 1969 with the Apollo 11 mission. That year, the lunar module Eagle landed on the surface of the Moon (see Figure 1). Landing on the Moon was an important step towards future space exploration and it was one that was viewed by the world. It is estimated that one billion people world-wide watched Neil Armstrong's first step onto the surface of the Moon and heard him say the words, "That's one small step for man, one giant leap for mankind!"

Since that time, tremendous strides have been made in science and technology, with developments continuing to advance. Space exploration is on the forefront of this progress. NASA hopes to send humans on extended missions to the Moon and other planetary bodies. Technological advances will allow astronauts to build outposts, conduct new research, and learn to live on a surface different from Earth’s. This will pave the way for eventual journeys to Mars and beyond.

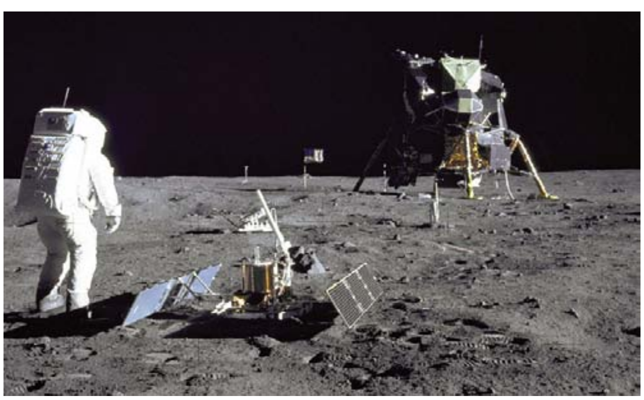

Figure 1: Apollo 11 lunar module Eagle

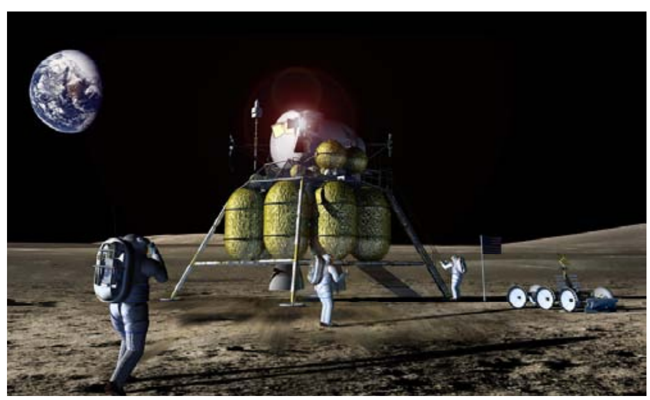

Figure 2: New lunar lander (NASA concept)

The human exploration missions to the Moon that took place during the Apollo program, and the robotic exploration missions of the Ranger, Surveyor, and Lunar Orbiter programs that preceded the Apollo astronauts, returned a wealth of information that helped develop a new scientific understanding of the Moon. After Apollo, additional scientific knowledge about the Moon was gained from the Clementine, Lunar Prospector, and SMART-1 missions - all robotic spacecraft that explored the Moon from lunar orbit. Based on the information gathered from all of these past missions, scientists, and engineers have proposed future landing sites that could provide clues to still unanswered questions about the Moon.

The proposed landing sites would bring us to locations where potential resources may be located. Hydrogen might be found in the form of water ice in permanently shadowed craters near the lunar polar region. Another chemical element that may be found in some of the potential landing sites is oxygen, probably bound in the crystalline minerals of the lunar soil.

Although it's been done before, landing spacecraft on the lunar surface is not easy. The Moon's gravitational force is 0.165 times the surface gravity on Earth. This difference in surface gravity affects the amount of thrust, or opposing gravitational force, needed to land. Another critical decision for landing on the lunar surface is the landing location. Landing safely means avoiding rocks, holes, or slopes large enough to damage the spacecraft. This is called hazard avoidance. Selecting landing sites that will be advantageous and interesting for science and engineering is also important.

On Apollo missions, the crew looked out the window and visually picked a safe landing location. NASA's latest development projects, with hazard avoidance technology, will enable astronauts to safely land and explore the surface of the Moon. On unpiloted missions, the spacecraft will have systems on board to automatically find the safe areas and land the spacecraft (see Figure 2).

Landing safely and learning to live on the Moon or other planetary bodies will give NASA a head start in exploring Mars and other destinations in the solar system.

Problem

Open the TI-Nspire™ document *Lunar_Landing.* Read through the problem set-up and complete the questions in the document.

A. What is the magnitude and direction of the acceleration of the spacecraft? Express your answer in m/s^2.

B. How long does it take to reach the surface from 100 m?

C. If the spacecraft has a mass of 20,000 kilograms (kg), what thrust in newtons (N) must the engines be exerting? Ignore the change in mass of the spacecraft due to propellant use. Include a force diagram with your solution.

D. In the NASA concept shown on page 1.1, the lander has four legs, each with a plate on the end that will set firmly on the surface. Each leg has a spring to act as a shock absorber and each shock will compress 30 centimeters (cm) when the leg plates touch the surface at a velocity of 0.5 m/s. Assume the engines' thrust goes instantly to zero at the time of contact with the surface and the lunar surface does not compress.

   I. What is the average acceleration of the vehicle after it touches the surface?

   II. What is the spring constant for each spring?