MATH AND SCIENCE @ WORK

AP* CALCULUS Student Edition

ASCENDING FROM THE MOON

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.

NASA is considering a new lander, which would be capable of landing a new generation of explorers on the surface of the Moon or perhaps even Mars.

Similar in design to the Apollo Lunar Excursion Module (LEM), this new lander would be much larger and would have the ability to carry four astronauts to the surface compared to the two-man Apollo LEM. The new lander would also have a much larger crew cabin volume, approximately 12 m^3 (424 ft^3), compared to the Apollo LEM, 6.65 m^3 (235 ft^3). Figure 1 shows a comparison of the new concept and the Apollo LEM.

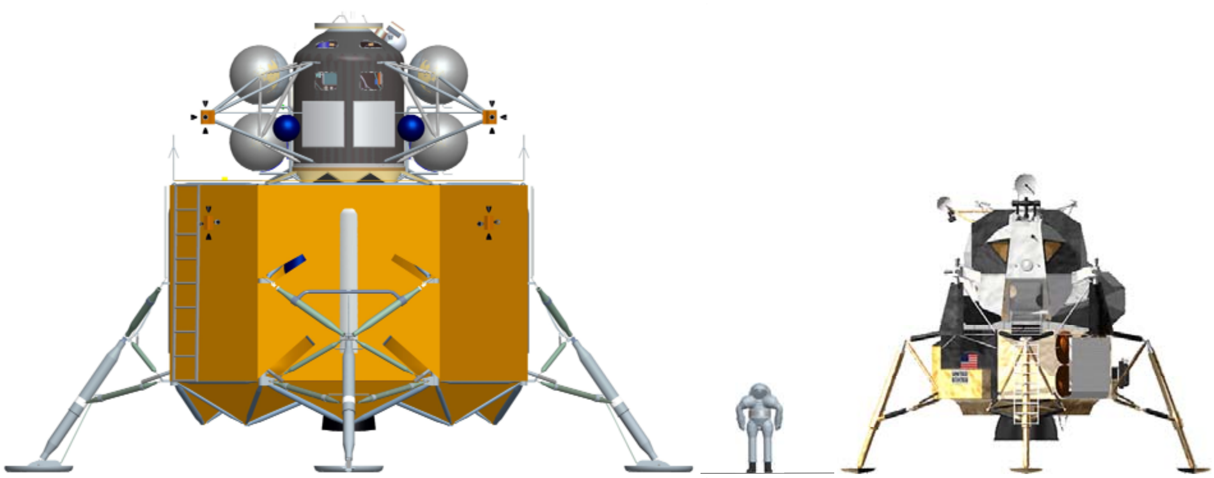

Figure 1: Comparison of the new lunar lander (NASA concept) and the Apollo LEM (not to scale)

The entire lander (See Figure 2, below) would consist of a descent stage, an ascent stage, and a large cargo volume that can be occupied by habitation modules or cargo. The descent stage provides the capability to perform an orbital insertion and landing. It also serves as the launch platform for the ascent stage and as a “flat bed truck” that could transport large cargo to the surface. The ascent stage functions as the flight deck/crew cabin for landing on the surface. It would provide a limited number of hours of surface stay, and would allow the crew to ascend back to orbit.

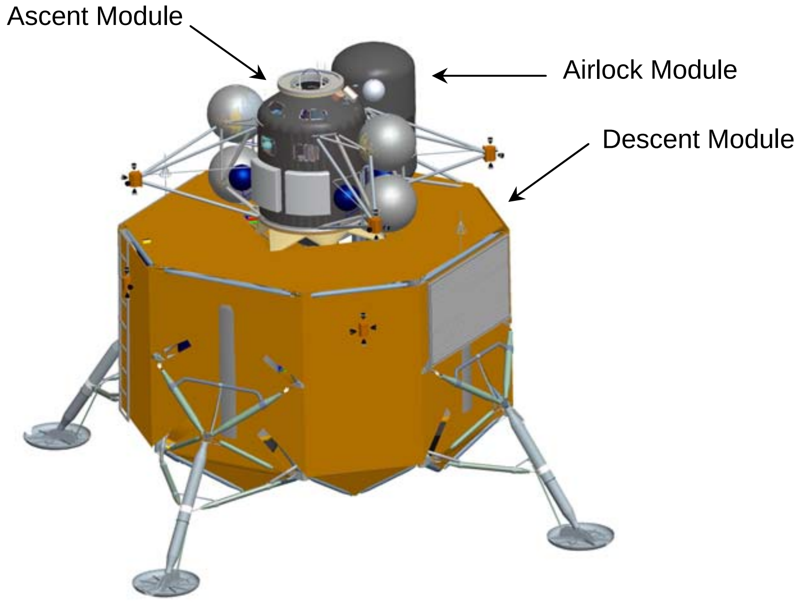

Figure 2: New lander (NASA Concept)

Problem

An astronaut, with camera at ground level, near a lunar outpost on the Moon is filming the liftoff of the ascent portion of the lander that is rising vertically according to the position equation $y(t)=0.683t^2$, where $y(t)$ is measured in meters and t is measured in seconds. The astronaut holding the camera is 1000 m from the base of the lander. See Figure 3.

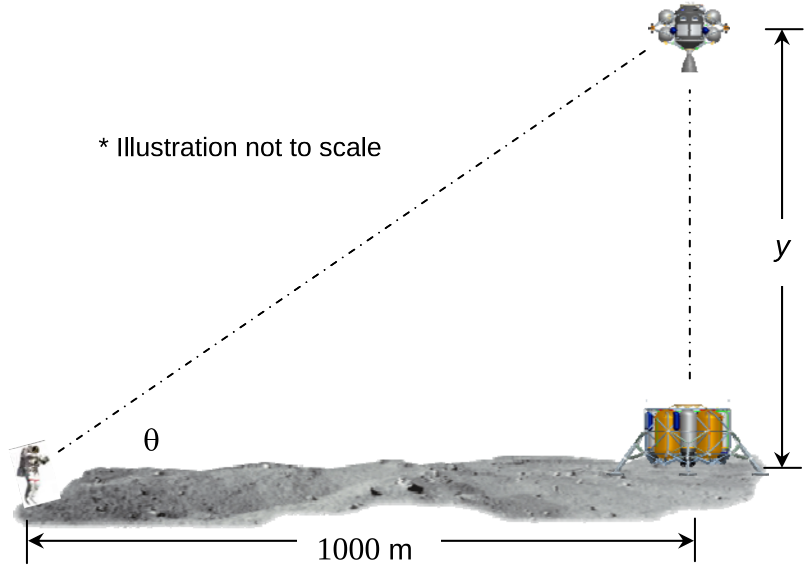

Figure 3: Problem Diagram

A. Using the Chain Rule, find the rate of change in the angle of elevation of the camera at 10 seconds after liftoff. Express your answer in rad/s and deg/s.

B. Describe the relationship verbally and graphically between the angle of elevation and time.

C. Use the graphing calculator to determine the time, *t*, when the rate of change in the angle of elevation is a maximum.

D. What is the angle of elevation when the rate of change in the angle of elevation is a maximum? Express your answer in radians and degree.