LESSON 18: NASA' S HEDGEHOG ROBOT

How do you explore a world without roads, air, or even gravity? Continued human exploration of space, either in person or through remote technology, continues to lead to technological breakthroughs as problems are encountered and overcome. A recent example of this phenomenon would be NASA's "hedgehog" design for robotic space exploration. There is an article on this "hedgehog robot" at "Space.com."

GRADES K-2

As mankind has explored space, different types of tools and vehicles have been created to carry out that exploration. From man's use of the Lunar Rover to travel across the surface of the moon, to the robots like Curiosity and Opportunity that were sent to travel the surface of Mars and take samples of what they found, different types of surfaces and different missions have led to new equipment being needed. The latest type of exploration equipment looks very different from those used so far. That is because it is planned to be used in a completely different environment. You may wish to compare the wheeled rovers with the "hedgehog" robot being designed for use on small, low-gravity space bodies such as comets and asteroids.

Here are some links to videos about rovers used on other worlds:

https://www.youtube.com/watch?v=7o3Oi9JWsyM (Lunar Rover)

https://www.youtube.com/watch?v=8Alq08Poqb0 (Curiosity's First Two Years on Mars)

http://www.nasa.gov/jpl/opportunity-rovers-7th-mars-winter-to-include-new-study-area
(Opportunity's marathon on Mars)

http://www.jpl.nasa.gov/missions/mars-exploration-rover-spirit-mer/ (Spirit rover on Mars)

GRADES 3-5

Along with the information and media from the K-2 lesson, you might ask students to brainstorm a list of terrain types on Earth that are similar to the surfaces the space program has explored so far. What terrain is most like the lunar surface? Which is similar to the surface of Mars? What types of existing vehicles have a design that resembles the Mars probes or the Lunar Rover? Has there ever been a type of vehicle that moves in the same way as the "hedgehog" robot?

GRADES 3-5 (CONTINUED)

You might even have students design their own exploration vehicles (manned or unmanned), and describe what obstacles it is able to overcome and how it will do so.

GRADES 6-8

Space exploration has produced some of mankind's most unique tools and technologies. A chief concern for any planetary space mission is locomotion – how will science vehicles move around to collect samples and perform scientific measurements once they have landed?

Moving around on a planet or an asteroid is very different from moving around on Earth – different planetary bodies vary widely in gravitational strength, atmospheric composition, and many other factors.

What is the best way to move from one point to another on different planets? There is no single "right" answer. While most vehicles have wheels, a new idea from NASA is to create a "hedgehog" rover which can roll and hop around. Why might this be advantageous?

GRADES 9-12

A new class of planetary exploration robot proposed by NASA is the so-called "hedgehog" lander, which can explore environments by rolling itself around. How does this work? Really, it's an example of the same basic Newtonian physics that control a spinning top – the conservation of angular momentum. By making adjustments to the angular momentum of the vehicle in three dimensions (x, y, and z), engineers can create specific forces on it and cause it to move however they want.

To illustrate the difficulty in moving around on a small body such as a comet or an asteroid, you can do a few calculations. The gravitational acceleration on the surface of Comet P67 Churyumov-Gerasimenko (the comet that Rosetta is orbiting and that Philae landed on) is about 10^{-4} m/s^2. If a wheeled vehicle were moving at one meter per second (about three feet per second, or two miles per hour) and hit a bump that pushed it upward at a speed of a tenth of its forward speed that vertical speed would be about 0.1 m/s. You can use the formulae for speed and height under constant acceleration to estimate how the vehicle would move. There are two formulae, one for speed and the other for height:

$$V_2 = V_1 - gt \qquad h = V_1 t - \frac{1}{2} g t^2$$

The quantity "V_2" is zero because we specify point "2" to be at the top of the vehicle's path. The quantity "V_1" is our initial vertical speed of 0.1 m/s. The quantity "g" is the gravitational acceleration, 10^{-4} m/s^2. We can solve for the time the vehicle spends moving up to get 1000 seconds. It will spend another 1000 seconds coming down, by the way. In the second equation, "h" is the greatest height the vehicle will reach.

You can calculate it; the result is 50 meters, or about 160 feet. Imagine how many times the vehicle can turn over while flying 160 feet in the air and staying aloft for over half an hour! Obviously a large wheeled rover is not a good choice for exploring a small comet or asteroid.

Sixty Years Ago in the Space Race:

July 2, 1956: The United States Army awarded Chrysler a contract to develop the Jupiter intermediate-range ballistic missile, with a range of 1,500 miles.

July 6, 1956: The first Nike-Cajun research rocket reached an altitude of 80 miles after launch from NACA's Wallops Island Test Station, VA.