Teacher's Guide for CYGNSS Learning Activity Module 1: Which Way is Down?

Astronaut Mark Lee participates in an extravehicular activity (EVA). Credit: NASA

LESSON OVERVIEW

The Cyclone Global Navigation Satellite System (CYGNSS) is a constellation of eight microsatellites that will use existing Global Positioning System (GPS) satellites to obtain estimates of surface winds near the central core of tropical hurricanes, including regions beneath

the eyewall and the intense inner-rain bands, that could not previously be measured from space. This information will allow NASA scientists and hurricane forecasters to provide improved advanced warning of hurricane intensification, movement and storm surge location/magnitude, thus aiding in the protection of human life and coastal community preparedness. Storm surge is an abnormal rise of water, over and above the expected water levels that would result from astronomical tides. In many cases, a significant fraction of a hurricane's impact on a coastal community is related to the destructive nature of the storm surge associated with hurricanes. The CYGNSS formation will orbit the Earth at around 500 km (310 miles), in a region of space called Low Earth Orbit (LEO).

This lesson is designed to introduce students to the concept of gravity in relation to every day objects near the surface, as well as those in orbit, such as CYGNSS, by demonstrating that the force of gravity is always present and pointed "down" toward the center of the Earth. Here we include ideas for classroom discussion as well as several additional resources for hands-on activities. This module is based on upper elementary curriculum requirements for the review of basic information, and portions may be omitted at the instructor's discretion.

NEXT GENERATION SCIENCE STANDARD

The following Next Generation Science Standard will be taught through this lesson:
5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down.

Clarification Statement: "Down" is a local description of the direction that points toward the center of the spherical Earth.

Assessment Boundary: Assessment does not include mathematical representation of gravitational force.

BACKGROUND INFORMATION

The observed effects of gravity on an object or system can be misleading. For example, the terms "zero-g" or "zero gravity" are often used to describe the apparent weightlessness of objects in orbit. Such descriptions often lead to the false belief that these objects have escaped Earth's gravity when, in fact, they are constantly in freefall around the Earth. By demonstrating that all objects near Earth, regardless of size, velocity, or altitude, experience the downward force of gravity toward the center of the Earth, it is possible to begin to understand the mechanics of orbit.

ENGAGE

To begin this activity, the instructor should engage students in a conversation about the basic concepts of gravity and orbit. Directed questions might include:

1. What is gravity? Why do objects "fall"?
2. What would happen if a skydiver were to jump from the edge of outer space?
3. What is astronaut Lee's orientation from the photo above? Which way is down?
4. What is an orbit? What are some examples of objects that orbit the Earth (weather satellites, the International Space Station (ISS), the moon, etc.)?

EXPLORE
Use the following activities and videos to help explore the questions in the discussion section.

1. *Notebook and Paper Experiment*. In this activity, direct the students to make a prediction about which object, a notebook or a single sheet of paper, will reach the ground first if dropped at the same time from the same height. The students should then conduct an experiment to test their prediction and note the result. Next, direct the students to predict what will happen if the notebook is placed directly on top of the paper and the pair are dropped together, followed by another experiment to test their prediction. Finally, direct the students to undertake a third prediction and experiment about what will happen if the paper is placed directly on top of the notebook and the pair are dropped together, once again. (Activity 1 in the Elaborate section, listed below, provides additional hands-on experience.)
2. Show the video of Felix Baumgartner's high altitude free-fall to demonstrate that the force of gravity on objects near the Earth is always in the same direction, "down" (toward the Earth), even when they are very high above the ground. Use this information to discuss the orientation of astronaut Sellers in the photo above.
3. Show portions of the two NASA films about the CYGNSS mission and the International Space Station that demonstrate man-made Earth orbiting satellites, and discuss the force of gravity on these objects. (Activities 2 and 3 in the Elaborate section, listed below, provide additional materials for this portion of the lesson.)

EXPLAIN
In this portion of the lesson, student are asked to construct explanations for their observations based upon the various concepts that they are exploring and learning. The following guidelines may be useful for discussing each the Exploration sections:

1. After noting the results of each of the experiments, discuss the force of gravity on each of the objects and note that sometimes the apparent difference in the behavior of different objects during freefall is due to other forces (air resistance), not differences in gravity, which is always directed toward the Earth. Would the results change if the objects were dropped from a higher starting point?
2. Since the force of gravity is always pointed down toward the Earth, Astronaut Lee is neary horizontal. Notice how the writing on the satellite next to him is upside down.
3. We know from our previous explorations that gravity is acting on the satellites, but they do not appear to be falling and, while the skydiver falls to Earth, Astoronaut Sellers does not. Why not? This is the difference between being at high altitude versus being in orbit.

ELABORATE
MICROGRAVITY EDUCATOR GUIDE This supplemental educator guide contains excellent background information accompanied by classroom activities that enable students to experiment with the forces and processes that scientists who study microgravity are investigating today.

You may also select from the activities listed on the website to provide supplemental hands-on experience for exploring the concept of gravity and orbit in the classroom:

GOING DOWN, ANYONE? The force of gravity is the focus of this demonstration using a ruler, string and a paper clip. Students observe that the Earth's gravity is always downward toward the center of the Earth.

3-2-1 BLAST OFF Students understand how satellites are placed in orbit by launching marbles into space, using two plastic rulers and clay. They describe the forces that determine the trajectory of flight.

MOONS, RINGS, AND RELATIONSHIPS This is an activity about gravity. Learners will design their own experiments to explore the fundamental force of gravity and then extend their thinking to how gravity acts to keep objects like moons and ring particles in orbit. They use the contexts of the solar system and the Saturn system to explore the nature of orbits. The lesson enables students to correct common misconceptions about gravity and orbits and to learn how orbital speed decreases as the distance from the object being orbited increases.

ASSESSMENT ACTIVITY

VOCABULARY
Define the following vocabulary terms in your own words:

1. Gravity

2. Orbit

3. Satellite

VISUALIZE
From each satellite, draw an arrow that points in the downward direction of gravity.