Satellite Orbital Activity

Objectives

Students Will:

- Learn how satellites orbit
- Explore the three orbital regions above Earth
- Learn about space debris and other damaging effects on satellites

Suggested Grade Level

6th – 8th grades

Subject Areas

Science and math

Timeline

30 minutes

Standards

NGSS Standards

- MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
- MS-PS2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
- MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
- MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.

21st Century Essential Skills

- Critical thinking/Problem solving
- Collaboration and Teamwork
- Communication
- Obtaining/evaluating/communicating ideas

Background

Satellites are complex machines that take a team to keep them in orbit. If it travels too fast, it can escape out of orbit. If it travels too slow, Gravity will pull on it and burn up through Earth's atmosphere. It takes a specific amount of fuel to reach a Low Earth Orbit (LEO), and the further the orbit is away from the surface of the Earth, the more fuel you will expend to

attaining that orbit. However, the closer to the Earth your orbit is, the greater effects of gravity play on your satellite and increased drag will cause you to expend more fuel during the life of the satellite. Lastly, space is a hostile environment. Striking debris, small pieces of materials from space and residue from past space projects can potentially damage or alter the course of your satellite. Geomagnetic storming from the sun can overcharge the upper atmosphere causing it to swell into your orbital path increasing drag and further frustrating your mission.

Students will simulate a satellite's orbital path by taking turns orbiting their satellites around the Earth. Based on their decisions and the chance of a dice roll, certain effects will take place that they will have to work to resolve to have the most successful satellite flight.

Vocabulary

Concentric circles, suborbital, Low Earth Orbit (LEO), Medium/Mid Earth Orbit (MEO) High Earth Orbit (HEO), geosynchronous, satellite, geomagnetic storming

Materials

- 1 Game board per group
- 1 Game piece marker per player (i.e. bottle cap)
- 100 Fuel Units per player (any tiny items, i.e. beads, beans, cut out printed coins)
- One six-sided die per group
- Paper/pen or pencil (optional)

Lesson

1. Print or create the gameboard prior to starting the lesson. The game board consists of a pattern of five concentric circles. The inner most circle is the Earth. The second circle out is a suborbital path; if your satellite stays in this orbit, it will tumble back to the Earth in ruins. The third through fifth circles are LEO, MEO, and HEO. You can fly your satellite safely in any circle from third to fifth.
2. Introduce this activity by talking about satellites and why we need them. Explain how satellites orbit the Earth (or any celestial object). Too close, Earth's gravity pulls them down; too far, it costs too much in fuel and spin out of orbit.
3. Explain vocabulary terms:
    a. Concentric circle: Circles within circles having a common center point
    b. Suborbital: Traveling around an object, but too close to Earth for satellites
    c. LEO: orbit closest to Earth; 160 – 1600km above Earth
    d. MEO: The region above LEO; up to 20000km above Earth
    e. HEO: The last region before leaving Earth's gravitational pull and achieves geosynchronous orbit; up to 330000km above Earth
    f. Geosynchronous: Orbiting at the same speed as the Earth
    g. Satellite: an object orbiting around another object
    h. Geomagnetic storming: electromagnetic rays from the sun
4. Explain to students they'll be playing a game to simulate satellites orbiting Earth. Divide students into groups of four. You direct satellite operations for a communications firm.

Your firm is about to launch a new satellite and they have directed you to ensure that the satellite stays in orbit for the longest possible duration. Luckily, you have been studying science and math, so you can put your skills to work on this task. Each player is allotted one hundred fuel units (F). They are subtracted from their reserve for each action they take. They are to use this fuel to get into and stay in orbit for as long as possible. On the players first turn, they must launch their satellite, which takes the following fuel unit costs:

a. LEO – 2F
b. MEO (Mid Orbit) – 4F
c. HEO (High Orbit) – 16 F

5. Explain the rules of the game. On each turn, a player moves his/her marker one-fourth of the distance around the Earth on their orbital path (circle) and encounter the following sequence of actions:
    a. Pay the fuel unit cost for the orbital path they are on at the start of this round.
        i. LEO – 6F
        ii. MEO – 3F
        iii. HEO – 1F
    b. Move one quarter turn around orbital path.
    c. Pay the fuel unit cost if you want to move to a higher orbit.
        i. Low to Mid – 2F
        ii. Mid to High – 12F
        iii. Low to High – 14F
    d. Roll the die to determine heading or environmental effects.
        i. Rolls 1 – 2: No effects; your satellite is on course
        ii. Rolls 3 – 4: Your satellite is striking debris and is off course; Pay the fuel unit cost to correct orbital path – 10F
        iii. Rolls 5: System error causes your satellite to gain one orbital level
        iv. Rolls 6: Geomagnetic storming causes your satellite to lose one orbital level
6. Explain to students if your satellite lost a level, you must wait until your next turn to move to another level of flight. If your satellite falls into the sub orbital path, you MUST move it to a higher level on your next turn, or it tumbles out of the atmosphere, striking the Earth and is destroyed. If you run out of fuel units, your satellite tumbles out of the atmosphere and is lost. If your satellite travels out of HEO, it is lost in space.
7. Explain to students that players continue flying their satellites until only one satellite is orbiting, or it is apparent that one satellite will survive longer than any others.
8. Discuss strategies used at the completion of the game. Which orbital path is the best to fly in? Why? What technologies might make satellites more efficient to operate?

Extensions

- Calculate orbital speeds of satellites. How does orbital acceleration work?
- Discover how satellites use trilateration when operating GPS.
- Visit http://www.discoverspace.org/ for more innovative ideas and resources.

Resources

Catalog of Earth Satellite Orbits. (n.d.). Retrieved from https://earthobservatory.nasa.gov/features/OrbitsCatalog

Game Board