Satellites

Friends and Neighbors in Space

Standards:

NGSS: 5-PS2.B; 5-ESS1.B; MS-PS2.B; MS-PS4.B; MS-ESS1.B

Objectives:

The Student will:

1. Discuss the historical and present roles of satellites.
2. Define different orbits used by satellites.
3. Investigate the role of sensors on satellites.

Background:

A **satellite** is simply any object that orbits a larger one. There are natural satellites called **moons** around almost every planet in our solar system. There are also several planets with artificial satellites orbiting them, taking pictures, using **sensors**, and sending lots of information about the planet back to scientists and researchers on earth.

The first artificial satellite was Sputnik 1, launched by the Soviet Union in October of 1957. The United States soon launched a satellite of their own, Explorer 1 in January 1958. The Explorer satellite had on board several scientific instruments and sensors resulting in the discovery of the Van Allen Radiation belts in the upper **atmosphere** around earth. By June 1961 there were over 100 artificial satellites in orbit around earth – today that number is over 6,000. Of these, only 2,500 or so are active; the rest are defunct. These satellites in orbit right now vary greatly in size, for example, the largest artificial satellite is the **International Space Station**, about the size of a football field, while the smallest satellites are **Cubesats**, only about 6 inches across.

Today's satellites are used in many applications from earth observation, environmental and weather, to communications and internet applications. Some satellites are used for the defense industry and their jobs are top secret, while others, like GPS satellites are free for everyone to use. Also, some satellites perform their mission on their own and some function as part of a satellite **constellation**. One of the most famous satellite constellations is Space

X's Starlink constellation that will provide internet access all over the world. It has over 955 satellites in orbit right now, and more launches are planned.
No matter what its job, all satellites have 4 parts:

1. A power system; usually batteries that are recharged with solar panels.
2. **Antenna** to facilitate communications with earth.
3. Control system such as a computer that has been programmed with instructions.
4. A **payload** the satellite uses for its mission, like sensors or a camera.

Another thing that is very important to the functioning of a satellite is its **orbit**. For example, a weather satellite will not need to orbit at the same altitude or inclination that a spy satellite would. There are many categories of orbits:

- LEO – Low Earth Orbit – an orbit that is between 100 to 1,000 miles in altitude.
- MEO – Medium Earth Orbit – an orbit that is between 6,300 and 12,500 miles in altitude.
- Equatorial – a LEO or MEO orbit that circles the earth at the equator.
- Polar - A LEO or MEO orbit that circles the earth 90 degrees from the equator, going from pole to pole.
- Inclined – an orbit that is neither equatorial nor polar, that is inclined a given number of degrees from the equator.
- Geostationary – an orbit that is 22,360 miles above the earth, allowing its orbit to be at the same speed as earth's rotation. The orbit is also equatorial so that the satellite stays over the same area of the earth at all times.
- Geosynchronous – an orbit that is 22,360 miles above the earth, allowing its orbit to be at the same speed as earth's rotation. The orbit is inclined so that it will always stay over the same longitude but will drift north and south over the degrees of inclination.

<u>Vocabulary</u>:

- <u>Antenna</u> – an instrument used to transmit or receive information using radio waves.
- <u>Atmosphere</u> – the layer of air surrounding the earth; it extends over 600 miles above the earth, getting thinner as altitude increases.
- <u>Constellation</u> – a group or cluster of related things.
- <u>Cubesat</u> – miniature satellites that are made of cubes sized $10cm^3$.
- <u>International Space Station</u> – orbiting science laboratory used and maintained by the U.S., Russia, Canada, Japan, as well as all of the countries of the European Space Agency.
- <u>Moon</u> – a natural satellite, a celestial body that orbits a planet.
- <u>Orbit</u> – the curved path an object follows around a larger planetary object.
- <u>Payload</u> – cargo carried by any vehicle. In the case of a satellite, usually tools or sensors needed for its mission.
- <u>Satellite</u> – anything that orbits a larger celestial body.
- <u>Sensor</u> – a device that detects or measures a physical property.

Supplies:

- String
- Scissors
- Foam balls
- Small boxes
- Playdough, clay, or paper and tape
- Tape
- Toothpicks or skewers
- Paper or science journal
- Pencils

Procedures:

Part One: Investigating Orbits

1. Cut 3 lengths of string, 18 inches, 24 inches and 30 inches.
2. Tie a foam ball onto one end of each string.
3. With the shortest string, spin the ball (lasso style) until it is in a stable orbit around your hand. Note how hard it was to establish a stable orbit, and how much it takes to maintain a stable orbit.
4. Repeat for the medium length, making the same notes.
5. Repeat for the longest orbit, making the same notes.
6. Discuss the fact that it is hardest to get the longest string to a stable orbit but once it is there, it takes less effort to keep it going. Satellite orbits are the same. LEO orbits are easiest to get to but take more energy to stay there.
7. Discuss the roles of satellites and how orbits are chosen: For example: What kind of satellites are in the highest orbits? (communication, weather) Why? Because they can see more of the earth at a time or because they need to see the same part of the earth all the time. On the other hand, why do some satellites need to be in Low Earth Orbit? Environmental and earth observing satellites are a great example, because they are looking in more detail and need to be closer.

Part Two: Sensing Landforms

Prep:

1. Cut along the sides of a small box, allowing the back to open, but not cutting it off. (the picture below is a spaghetti box; it has also been shortened).
2. Using clay, playdough, or simply wadded up paper and tape, build a 'landscape' across the bottom of the box. It should have noticeable peaks and valleys.
3. Using toothpicks or skewers, depending on the size of your box, insert several into the top of the box. You should be able to touch the top of your landform

with the bottom of the toothpick or skewer and still see the top of it outside the box.

4. The number of toothpicks or skewers will vary based on the size of your box, but there should be enough to trace the shape of your landform reasonably well.
5. Make several of these so you can split your class into groups. Vary the landforms so that they can compare results.
6. Take the toothpicks or skewers out and tape the box shut before giving to students.

Procedure:

1. Give each group a closed box. Explain that many satellites use sensors to study the earth. The satellite cannot actually 'see' the landforms through clouds or trees, but they can sense what is there by sending out signals (in the form of electromagnetic waves) and then analyzing what bounces back.
2. We are going to send out some signals into an area that we cannot see and then analyze what information we get from that. In this case the section of earth we are going to study is obscured by the box. The signals we are going to send out are the toothpicks. Give each group some toothpicks.
3. Have the students carefully put the toothpicks into the holes you punched into the top of the box. Remind them to stop when they feel resistance so that they aren't punching holes in the landforms.
4. When they are finished ask them to look at the 'signals' showing. Have them analyze these signals and draw what they think the landform below looks like.
5. Once they have finished this, let them open the box and see what the landform really looks like – have them draw this as well.
6. Have the students compare the drawings. Are they the same? Why or why not? Ask the students how they could improve the information (adding more signals? Using different signals? Doing more than one row?) Explain that this is why many earth imaging satellites have several sensors, all measuring different kinds of energy so that they get a more complete picture.

Credits:

https://www.space.com/24839-satellites.html

https://www.weforum.org/agenda/2020/10/visualizing-easrth-satellites-sapce-spacex/#:~:text=Right%20now%2C%20there%20are%20nearly,globe%20in%20April%20of%202020.

https://www.britannica.com/technology/satellite-communication/How-satellites-work#ref1096580

https://sciencing.com/thick-thin-earths-atmosphere-19740.html