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Lesson 4: What Makes Up An Artificial Satellite?

Objectives:

- Students will learn the components of a satellite with analogies to humans: a living organism needing fuel (food and air) with a power plant (heart and circulation system), in order to receive data (senses and nervous system), process it (brain), and communicate it to others (oral and written).
- Students will construct paper models of various satellites and experiment with different types of attitude control and communications (one or more activity).
- Students individually or in small groups will demonstrate the understanding of the components of a satellite by constructing a model of an artificial satellite and writing a report to explain its purpose.

Estimated Lesson Time:

One week or more

Classroom strategies:

Begin with vocabulary and teacher directs the discussion of how a satellite is "alive" with analogies to a human being "fueled," receiving data, processing it, and communicating it. Use activities to demonstrate how the various components work. As you go, let the students know that they will be doing a project associated with this lesson and that they should be thinking about what kind of satellite they would like to build on their own. Assign the homework at the end of the activities and review the projects after the allotted time (this will bridge over into the next lesson).

Science Background Information:

A satellite is a type of robot that mimics many human functions. It must be fueled, convert that fuel into appropriate kinds of power, react to the environment (for instance to maintain balance), and collect, process, and communicate data. Each satellite has the core components to accomplish these functions, but each may do so in different specific ways. Each satellite is designed with a "payload"

to make a certain measurement depending upon the application. The satellite's "eyes, ears, and touch" might be a telescope, a camera, a radio wave antenna, a particle detector, a thermometer, or a pressure sensor.

Breakdown of satellite parts:

Power systems - all convert one form of energy (food and muscles) to electricity; typically satellites use solar panels and batteries

Solar - solar cells collect energy from Sun in form of light (used in some calculators)

Nuclear - converts energy stored in radioactive material

Battery - stores electrical energy chemically (like rechargeable batteries)

Attitude Control - needed to maintain a satellite's orientation. The orientation is how the satellite is positioned, for example it might need to have one side (the side with the solar cells) always directly facing the Sun and another side (one with a camera or antenna) always pointing toward the Earth.

Magnetic - uses magnetic fields in space to position satellite

Gyroscope - uses a spinning wheel to maintain a certain orientation

Gas jets - uses puffs of gas from a pressurized tank to change the orientation

Antenna is used to receive radio wave information from the ground (uplink) about how the satellite should be operated or controlled, and also to transmit radio wave data collected on the satellite back to Earth (downlink). The antenna is connected to a radio. The antenna collects waves (like on a cordless phone or on a boom box) and these are processed in the radio. The radio also produces radio waves that it sends out through the antenna (like a TV station transmitter). Radio wave information is sent back to Earth in a form that is read by a computer and then converted into another form (for example, time and data in the form of numbers) that humans can interpret

Payload - are the computers and sensors that collect the required information and might include: cameras, telescopes, thermometers, wind gauges, pressure gauges, particle detectors. The computer is used to process the measurements, and convert it into a form that the radio can transmit through the antenna.

Vocabulary:

1. Attitude control -

2. Solar cells -
3. Nuclear - Applied to research and fields of study concerned with the atomic nucleus.
4. Downlink -
5. Uplink -
6. Transmit - To cause (a thing) to pass, go, or be conveyed to another person, place, or thing; to send across an intervening space; to convey, transfer.
7. Sensor - A device giving a signal for the detection or measurement of a physical property to which it responds.
8. Gauge - A fixed or standard measure or scale of measurement, the measure to which a thing must conform.
9. Detector - An instrument or device for detecting the presence of anything.
10. Particle - A very minute portion or quantity of matter; the smallest sensible, component part of an aggregation or mass; formerly often = atom or molecule; in Dynamics, a minute mass of matter which while still having inertia and attraction is treated as a point, i.e. as having no magnitude. In Physics now applied esp. to the constituents of atoms and to other sub-atomic entities (some of which are now regarded as likely to be composite in nature)
11. Antenna - An aerial wire or other device for radiating or receiving radio waves.
12. Payload -
13. Radio waves -
14. Gyroscope - An instrument designed to illustrate the dynamics of rotating bodies, and consisting essentially of a solid rotating wheel mounted in a ring, and having its axis free to turn in any direction. Also used, in various modifications or in conjunction with other equipment, to provide a horizontal or vertical reference direction (as in the artificial horizon and the gyro-compass), to stabilize ships, mono-rail vehicles, etc., and to measure angular velocity and angular acceleration (as in the turn-and-bank indicator and other navigational devices). The form of this apparatus invented by Foucault is contrived so as to render evident the rotation of the earth, through the tendency of the wheel (being free from the influence of disturbing forces) to maintain its rotation in a fixed plane independently of the earth's motion.
15. Rechargeable battery - An apparatus consisting of a series of cells, each containing the essentials for producing voltaic electricity, connected together. Also used of any such apparatus for producing voltaic electricity, whether of one cell or more. Rechargeable batteries are those that can be replenished.

Materials and Equipment:

References on various satellites. Pictures of satellites (a typical example of each kind). Videos. Paper models of satellites. Scissors. Paper. Glue. Tape. Paper clips. Magnets. String. Wheel or gyroscope. Blindfold.

Advance Preparation:

Gather appropriate materials.

Activities:

Construct Satellite Model. Use paper cut out model of a simple satellite and have student groups construct them. Students will then use these to explore various aspects of satellite systems with the following exercises.

Attitude Control. Get a front wheel from a bike and hold it on each side of the axle. Have the student now move their hands and note that there is no resistance. Now spin it fast, again holding each end of the axle and have them now try to change the position of their hands. The wheel will resist you trying to change its orientation. If a bike wheel is not available, you can use a gyroscope.

Use a magnet taped on the student's satellites on a string and then see how it moves when you bring another magnet near it. What happens when the magnet is far away? What happens when the magnet is flipped?

Communications. Spinning someone blindfolded (satellite) and have another person guiding them through words (communication) to a predetermined destination (example of attitude control). Show the effects of noise and challenge the students to devise their own strategies for overcoming noise.

Homework Assignment (at end of activities):

Have students write in their journal how they would design their own satellite. Have the students write what the satellite is supposed to do or measure. Give the satellite an appropriate name. Describe what instruments you might want to include on the satellite. Also write what other parts of the satellite will be needed. This forms the basis of the project.

Project:

Use materials you find in your home to construct your own satellite guided by a provided checklist. Have the student explain the various components of the satellite, what the satellite is designed to measure, and how the satellite collects the relevant data for that purpose. Students would turn in the satellite with a written report. Students would then present their satellites to the class and the class would critique each project in a question period.

(Note: We should design a checklist as follows: Provide a directed worksheet with a checklist of what should be included on the satellite. For instance, what is the name of the satellite, what is the satellite designed to do, what instruments are on the satellite to make the relevant measurements, and what are the other

components of the satellite (power system, attitude control, communications, etc.). This worksheet will give the students a direction for constructing their own satellite and give the teacher a chance to help those who need it.)

References:

Connections:

Literature:

Music: Star Wars and the Death Star (John Williams and the Boston Pops)

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