The Relationship Between Science and Technology

Lesson Procedures

Part 1: Talk to the students about satellites and how that technology helps us. Discuss different kinds of satellites and their functions. Ask them how they think a satellite changes its orientation in space. Let them explore this concept of **attitude control** and the difficulties scientists face when trying to design a spacecraft that could adjust rapidly and repeatedly. Technology helps scientists solve this problem.

Show the students Video 4: Gamma-ray Burst Theories [Time – 4:11]. Ask the students to focus on how new technologies help us gain more understanding in science. Also, ask the students to note how quickly the Swift satellite has to move in order to view the gamma-ray bursts.

Part 2: When NASA scientists or engineers talk about attitude, they mean the way that the satellite is positioned in 3-dimensional space. Attitude is in effect, the way that the satellite is pointed. In order for the satellite to point in the right direction, attitude must be monitored and controlled. If even a tiny mistake in the way the satellite is pointed isn't corrected, the satellite can end up looking at an entirely different part of the sky.

Recruit a volunteer from among the students. Ask the student to sit on the swivel chair and try to turn around it. Most students will use their feet to anchor themselves and turn. Now ask the student to pick up his or her feet and try to swivel in the chair. Tell the students that this is the problem the scientists face with getting a satellite to change its pointing direction. There are no anchors in space.

Part 3: Ask students: What are some ways are that scientists might solve this problem?

Two Possible Solutions:
Solution One – Tiny thrusters that contain compressed gasses control attitude. These tiny thrusters can be pointed in different directions. Firing the thrusters releases gas that makes the small adjustments needed to get the ship back on course (Picture 1: Attitude Thruster). What are some disadvantages to using thrusters? (Possible answers: storage capacity or contamination of optics)

Solution Two – Introduce the activity as one possible solution that uses technology to allow the satellite to turn rapidly and repeatedly.

Ask the student sitting on the swivel chair to again pick his or her feet off the floor (Picture 2). Hand the student the wheel with handles on it. Ask the student to hold the wheel by the handles while another student gets the wheel spinning as fast as possible. The student holding the wheel should tilt the wheel. If the swivel chair has sufficient low friction, the chair should start to turn.

Explain to the students how a rotating bicycle has angular momentum. Angular momentum is an object's tendency to continue to spin, around an axis which is pointed in a specific direction in space. Because of this spinning motion, the satellite will keep pointing in the same direction until another force changes the direction of the spin axis.

Both thrusters and momentum wheels can be used to change direction. (Swift uses momentum wheels.)

Suppose you are now sitting on the chair with the bicycle wheel spinning. One way to change the angular momentum of the bicycle wheel is to change the orientation of its spin axis. To do this, you must exert a twisting motion, called a torque, on the wheel. The bicycle wheel will then exert an equal and opposite torque on you. (That's because for every action there is an equal and opposite reaction.) When you twist the bicycle wheel in space, the bicycle wheel will twist you the opposite way. If you are sitting on a low friction pivot, the twisting motion of the bicycle wheel will cause you to turn. The change in angular momentum of the wheel is compensated for by your own change in angular momentum. The system as a whole ends up obeying the principle of conversation of angular momentum. It is this angular momentum that creates a problem for attitude control. Many satellites spin very quickly about their own axes. This spin gives the satellite the angular momentum. The satellite thus tends to maintain a fixed orientation, or direction, in space. However, this solution can be a problem in satellites like Swift that need to turn directions all the time.

Assessment Strategies

Ask the students to think about two ways that scientists can get the Swift satellite to change directions. Have them tell you which of the two ways would be best, given that Swift must change directions several times a day for two or more years. Students can discuss the options in teams and provide a recommendation to the rest of the class.

Vocabulary

Angular Momentum – an object's tendency to continue to spin around an axis which is pointed in a specific direction in space
Attitude – the way that a spacecraft or satellite is positioned in 3-dimensional space, or is "pointed"
Momentum – an object's tendency to move at a constant speed along a straight path
Thrusters – containers of gas on a spacecraft or satellite that cause a spacecraft or satellite to move in a particular direction when the gas is released
Torque – a twisting motion that results from a force acting along a line that is off the object's spin axis

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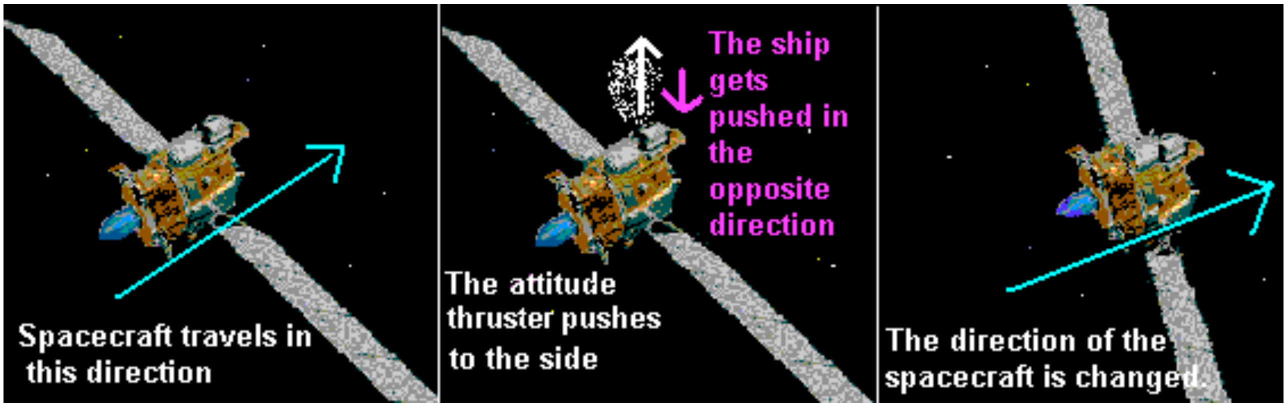
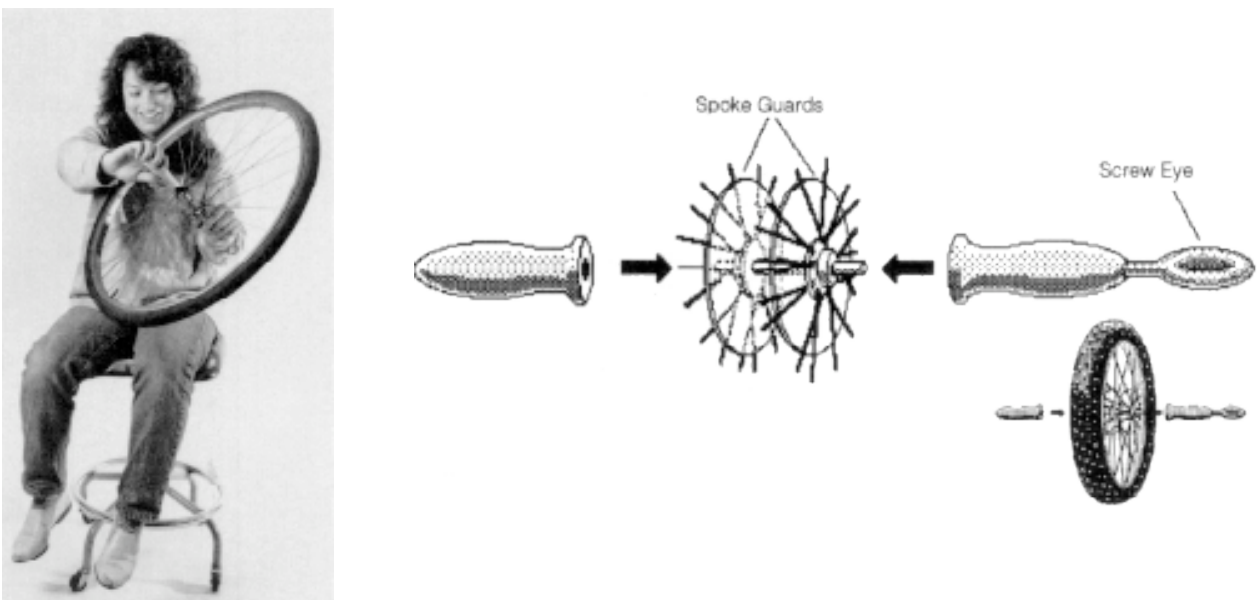
Picture 1: Attitude Thruster
(Source: http://www.qrg.northwestern.edu/projects/vss/docs/Propulsion/2-what-is-attitude-control.html)





Picture 2: This is how the bicycle wheel should look like to complete the activity. (See source for elaboration: http://www.exploratorium.edu/snacks/bicycle_wheel_gyro.html