NASA Lewis Research Center Open House

Grades 5-8

Discovery Future Engineers and Scientists in Training

Human Exploration and Development of Space

Microgravity

Disturbing Experiments

Background

When a spacecraft is in orbit around Earth, it is not flying like an airplane. It actually is falling around Earth. Why doesn’t a spacecraft crash back to Earth? The scientist Sir Isaac Newton first envisioned how an object could orbit Earth back in the late 1600s. He imagined a cannon sitting high on a mountain. When the cannon fired the cannon ball, it traveled up a certain distance before falling down to Earth. A more powerful cannon could shoot a cannon ball farther. The faster the cannon ball went the farther the distance it would travel. Newton theorized that if enough gun powder were used, then the cannon ball would go completely around Earth. In the 1900s technology advanced, making it possible for a spacecraft to go fast enough to orbit Earth.

Near the beginning of the 1900s, another great scientist named Albert Einstein realized that if an individual were falling from a building, he or she would feel as if he or she did not weigh anything (until the individual hit the ground). NASA scientists call this special condition when something falls (to Earth or around Earth), and its weight appears to be smaller than normal, microgravity. Scientists do experiments in microgravity because it lets them study science in different ways than they can on Earth. On Earth, gravity acts on objects, pulling on them. In microgravity, the effect of gravity does not influence experiments like it does on Earth.

Look at the picture of the Space Shuttle Orbiter falling around Earth. The shuttle can change which way it points while in orbit. Sometimes the nose is closer to Earth. At other times the tail is closer to Earth. Engineers and scientists at Mission Control use a special point in the shuttle, called the center of mass, to keep track of the shuttle’s precise position.

During shuttle missions, NASA engineers keep track of where the shuttle’s center of mass is. They do this by calculating how the mass of everything onboard the shuttle is distributed including equipment, experiments, supplies, etc. The center of mass can change during the course of the mission. The crew may release a satellite into space. The shuttle consumes fuel and waste water is jettisoned. Engineers must take such factors into consideration when calculating the center of mass.

The path that the center of mass follows is the shuttle’s orbital path (the path of the orbit). Any point on the shuttle that does not follow the same orbital path as the center of mass is actually in a different orbit around Earth. Being in a different orbit than the center of mass, can actually bother experiments just like gravity does on Earth. So, experiments are situated to take advantage of the center of mass.

Vibrations also can affect experiments on Earth and in orbit. The slightest shaking on the shuttle can actually disturb experiments. The air conditioning and heat the crew needs, computers with fans in them, and crew members exercising on stationary bikes or treadmills can all cause vibrations that can damage experiment results. To prevent this interference astronauts conduct experiments far away from the vibrations or at times when there are no such disturbances.

Activity

This activity has students discover where they should place a paper clip payload (the experiment) on a spacecraft of their own design. Students cut out an asymmetrical spacecraft from a stiff piece of paper, find its center of mass, and attach a paper clip at this point to represent the payload.

Materials:
- Thin cardboard or heavy construction paper
- Scissors
- String
- Pencil
- Paper clips
- Washer

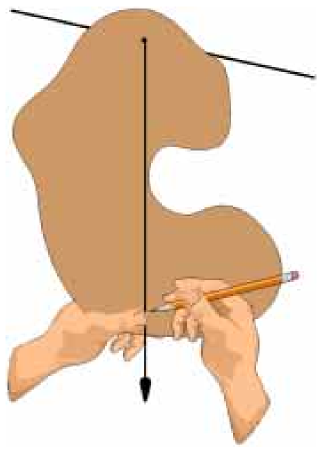
1. Draw and cut out a spacecraft from a piece of stiff paper. Predict where you think the center of mass is for this spacecraft.

2. Straighten out a paper clip so one end is a hook and the other end can punch holes. Poke two small holes through the paper, on opposite sides of the spacecraft.

3. Thread the paper clip through one of the holes and hang the spacecraft from the paper clip.

4. Attach a washer to the end of the string. Tie a small loop at the other end of the string. Take this plumb line and hang the loop on the paper clip hook, too.

5. Carefully mark an X where the string crosses the bottom edge of the spacecraft.



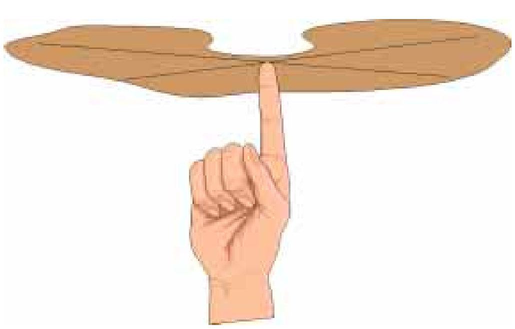
6. Take the spacecraft off the paper clip. Draw a line connecting the X to the hole you used.

7. Repeat steps 3 through 6 using the other hole.

8. Try to balance the shape, with your finger at the point where the two lines cross. This is the shape's center of mass. Gravity pulls down equally everywhere around this point, so it is also called the center of gravity.

9. Attach the payload to the center of mass.

For small, regularly shaped objects made out of the same material, like a book, the center of mass is very close to the center of the object. You can find this rather easily on Earth by trying to balance the book on your finger. This works because gravity pulls down on the book almost as if gravity were only acting on the center of mass. For this reason, this point is sometimes called the center of gravity. The balancing point of oddly shaped objects or ones made out of different materials is harder to find.



Try This At Home!

How does vibration disturb experiments? Try this simple experiment that shows how shaking can affect surface tension.

Pour water into a glass until it is almost full. Once the water is still, carefully place a metal paper clip on the surface of the water. Surface tension makes the paper clip stay on top, even though the paper clip is more dense than the water. Now, try tapping on the table where the glass is sitting. The water moves. Can you hit the table hard enough to make the paper clip sink? If not, try tapping the glass. Eventually, the water will shake enough to break the surface tension that supports the clip, making the clip fall to the bottom of the glass.

The NASA Lewis Research Center Connection

The Acceleration Measurement Program is located at Lewis and is part of NASA's Microgravity Research Program. Engineers, scientists, computer programmers, managers, secretaries, and graphic artists work together on the program. Each plays a role in the design and construction of accelerometer systems to measure the microgravity environment of orbiting spacecraft and other research vehicles. One aspect of this work is to determine payload placement requirements, and address various vibration levels and types.

Learn More by Using the World Wide Web

More information about the Acceleration Measurement Program at Lewis is available at:
http://www.lerc.nasa.gov/WWW/MMAP/

More information about NASA Microgravity Research Program is available at:
http://microgravity.msfc.nasa.gov/

More information about NASA Lewis Research Center is available at:
http://www.lerc.nasa.gov/

The Microgravity teacher's guide for grades 5-12 can be accessed at:
http://spacelink.nasa.gov/Instructional.Materials/NASA.Educational.Products/Microgravity/

This activity is adapted from "Balancing Act" in *The Science Book of Gravity*, by Neil Ardley, Gulliver Books, 1992.