MICROGRAVITY—Demonstration

Students observe how microgravity is created by free-fall.
Adapted from a lesson plan provided by NASA

LESSON PLAN

Introduction
Gravity is a force that governs motion throughout the universe. It holds us to the ground, and it keeps the moon in orbit around Earth and Earth in orbit around the sun.

Many people mistakenly think that gravity does not exist in space. However, typical orbital altitudes for human spaceflight vary between 120 - 360 miles above Earth's surface. The gravitational field is still quite strong in these regions, since this is only about 1.8 percent the distance to the moon. Earth's gravitational field at about 250 miles above the surface is 88.8 percent of its strength at the surface. Therefore, orbiting spacecraft, like the space shuttle or space station, are kept in orbit around Earth by gravity.

The nature of gravity was first described by Sir Isaac Newton, more than 300 years ago. Gravity is the attraction between any two masses, most apparent when one mass is very large (like Earth). The acceleration of an object toward the ground caused by gravity alone, near the surface of Earth, is called "normal gravity," or 1g. This acceleration is equal to 32.2 ft./sec^2 (9.8 m/sec^2).

If you drop an apple on Earth, it falls at 1g. If an astronaut on the space station drops an apple, it falls too. It just doesn't look like it's falling. That's because they're all falling together: the apple, the astronaut and the station. But they're not falling towards Earth, they're falling around it. Because they're all falling at the same rate, objects inside of the station appear to float in a state we call "zero gravity" (0g), or more accurately microgravity (1x10^{-6} g.)

Creating Microgravity

The condition of microgravity comes about whenever an object is in free fall. That is, it falls faster and faster, accelerating with exactly the acceleration due to gravity (1g). As soon as you drop something (like an apple) it is in a state of free fall. The same is true if you throw something; it immediately starts falling towards Earth. But how does something fall around Earth?

Newton developed a thought experiment to demonstrate this concept. Imagine placing a cannon at the top of a very tall mountain.

Grade Level: 6—8

National Science Education Standards:
Unifying Concepts and Processes, Science as Inquiry, Physical Science, Earth and Space Science, Science and Technology, Science in Personal and Social Perspective, History and Nature of Science.

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Materials Required:
- Quarter
- Piece of paper—smaller than a quarter
- Playing card or 3”x5” card

Once fired, a cannonball falls to Earth. The greater the speed, the farther it will travel before landing. If fired with the proper speed, the cannonball would achieve a state of continuous free-fall around Earth, which we call orbit. The same principle applies to the space shuttle or space station. While objects inside them appear to be floating and motionless, they are actually traveling at the same orbital speed as their spacecraft: 17,500 miles per hour (28,000 km per hour)!

Lesson Objective:
In this lesson, students will learn about microgravity during free-fall and how it relates to microgravity in space flight.

Learning Objectives:

The students will
- Learn about microgravity.
- Learn why astronauts appear to "float" in space.
- Conduct the demonstration themselves and observe and discuss the science principles that are illustrated.

Procedures:

- Cut or tear a piece of paper so that it is slightly smaller than a quarter. If placed on top of the quarter, no corners of the paper should stick out.
- Ask the students to drop the coin and the slip of paper from the same height, at the same time and have the paper and coin reach the ground at the same instant.
- Solution 1: Put the paper on top of the coin while making sure that there aren't any corners of the paper sticking out over the edge of the coin. Press the paper down on the coin to maximize the contact between the two surfaces. The goal is to keep the air from moving under the paper and lifting it from the coin. Then drop the coin and paper together, ensuing the coin remains horizontal as it falls.
- Solution 2: Placing the paper under the coin should also work because the coin presses down on the paper as both fall to the ground. The paper-under –the-coin variation is more difficult to set-up. The students must quickly remove their finger from the paper and drop the coin and paper without shifting the paper's position under the coin.

Variation:
- Drop a playing card or 3"x5" card, thin edge downward. Does it fall perfectly straight?
- Now try holding the card flat and drooping it. In the first case, the thin edge slices through the air and is easily pushed off course by slight differences in the air resistance met by the two sides of the card. In the second case, air strikes the bottom face of the card, but not the top face. The fall is slower, more balanced and straighter.

Resources:

- National Aeronautics and Space Administration (NASA)

- NASA Microgravity Site for Students and Educators
  http://www.nasa.gov/audience/foreducators/microgravity/home/index.html

- NASA -- What is Microgravity?
  http://www.nasa.gov/centers/glenn/shuttlestation/station/microgex.html

- Liftoff to Learning: Microgravity Video Clips
  http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/What_Is_Microgravity.html

  Why Do Astronauts Float in Space? Video
  Gravity on Earth Versus Gravity in Space: What's the Difference? Video
  Why Do Astronauts Float Inside the Space Shuttle? Video
  Shoot a Cannonball into Orbit! Simulation http://spaceplace.nasa.gov/how-orbits-work/redirected/