Science Lesson Plan: Microgravity: Do Try This at Home!

Learning Outcomes

(corresponding to science standards for all ages)

1. Connect classroom learning with everyday life
2. Identify questions that can be answered through scientific investigations
3. Use appropriate tools and techniques to gather, analyze, and interpret data
4. Think critically and logically to make the relationships between evidence and explanations
5. Understand how an object's motion is the result of all forces acting on it

Introduction – Building Connections to Curriculum

Open Demonstration Activity Objectives:

1. Review the law of "What comes up must come down."
2. Create an interest in applying the understanding of gravity.

Material(s) List: Tennis ball

Ask students: What will happen when I let go of the ball?

Yes, the ball will fall to the floor.

Ask students: Have you ever wondered why the moon, or the sun, or stars don't fall from the sky? Or how does an airplane can stay in the air?

Answers will vary, from the speed of the plane, to an explanation of gravity. Explain that the moon will not come crashing down because of a great force known as gravity, the force that pulls objects down towards the center of the earth. Even though everything is held to the ground by this mighty force, gravity loses its force as it gets farther away from the center of the earth. The pull of gravity is not as strong far above the Earth as it is close to the Earth's ground.

Discussion– Building Connections to Ideas

Ask students: Have you ever been free falling like the ball?
Answers will vary.

Sure you probably have, for example, when you're in an elevator that starts moving downward, you feel lighter. If you were standing on a scale in the elevator, you would notice the weight reading would drop. The opposite would happen when the elevator stopped. If for some reason you've never been on a ride in an elevator, how about when you're speeding down a steep hill riding in a car, or taking a ride in a roller coaster? What causes this free falling feeling?

Your stomach is used to feeling weight. When this feeling disappears for just a few seconds, you may feel queasy because of this new sensation.

Gravity is constantly pulling us against whatever we're standing or sitting on. A chair supports you and keeps you from falling. If the chair suddenly disappears, you fall toward the floor, or rather the Earth. For the split second you are free falling. Here's what is happening: Objects fall because of Earth's gravity, when gravity is the only force affecting an object's fall, like when you fall out of a chair, you're free falling. The effects of being in free fall are identical to the effects of being in deep space, or what is known as microgravity.

What is microgravity?
Gravity is a force that rules motion throughout the universe. It holds us to the ground and keeps the Earth in orbit around the Sun. That's why the moon, the sun, and the stars stay up in the sky.

Microgravity describes the environment in space flight. Space has a very weak gravitational effect (one-millionth of what is felt on Earth) and is sometimes called a state of "weightlessness." Microgravity happens when an object is in "free fall." In free fall, an object falls faster and faster, speeding up with exactly the speed of the gravity

pulling it to earth. Objects travelling around the Earth in a state of continuous free fall, or orbit, are weightless even though their mass remains the same because they are moving together, so it feels like they aren't moving at all!

This can boggle the mind. Because gravity is an invisible force of nature, it's often difficult to explain.

Standing on the Shoulders of Giants

Astronomer Galileo

An Italian in the 1500s named Galileo is the first Astronomer to figure out our Earth is not the center of the universe, and that all other stars and planets do not revolve around Earth, as was the teaching in his day. He is famous for doing experiments to prove or to discover what we now call scientific facts. One of his famous experiments was designed to prove that Aristotle was wrong in his position on gravity. That is that a heavier object, like a book, will not fall faster than a lighter object, like a feather, *because of gravity*.

Greek Philosopher Aristotle

Ask students: What do you know about Aristotle?

Answers will vary. Make mention that he was a Greek philosopher who had a very high IQ, and his teachings were widespread covering math, logic politics, ethics, and many more academic subjects.

Ask students: By a show of hands, how many in here think that Aristotle is right?

Ask students: By a show of hands, how many in here think that Galileo is right?

Demonstration Activity: Aristotle versus Galileo

Material(s) List:

- A heavy book
- A turkey feather

Step 1: Drop the book and the feather from a standing position, and see which one falls faster.

Ask students: Why did the book fall faster than the feather?
Answer will probably be that the book is heavier.

Galileo argues that the reason why the feather falls slower is because the air is blocking the feather from falling as fast as the book, and if both the book and the air were dropped in a vacuum, both would fall at the same rate of speed. Our universe is likened to a vacuum.
Ask students: How many of you think that Galileo is right?
Many experiments in space and in vacuum containers in science labs have shown Galileo is correct. Galileo contradicted Aristotle, saying that air resistance is to blame, *not gravity*.

Step 2: Now place the feather on top of the book, and drop the book. By placing the feather on the book, the air is no longer acting as a resisting force on the feather, so they both the book and the feather fall together.

Scientist, Sir Isaac Newton
Nearly a hundred years after Galileo lived an English scientist name Sir Isaac Newton (1600s) who, as the story goes, after an apple fell on his head, he wondered why things fall down, and not up, or sideways. Sir Isaac Newton discovered the force of gravity, or rather, depending on the direction of movement, how far away two objects are and how fast they are moving, could affect each other's course and/or speed. He believed the bigger object would affect the smaller object. In other words, the Earth's gravity affected the apples gravity, pulling the apple down to Earth, rather than sideways into space.

Demonstration Activity Objectives: Demonstrate how gravity is the force that planets use to orbit the sun.
Material(s) List: A small ball attached on the end of a string
Holding the string away from your body, begin swinging it around you.

Observations:

As you swing it around, you are continually pulling the ball towards your hand, just as the gravity of the Sun pulls the planets in, but the motion sideways keeps the ball swinging around. Without that sideways motion, it would fall to the center, and without the pull toward the center it would go flying off in a straight line. Let go of the string and the ball will go flying off in a straight line.

Sir Isaac Newton is also known for a very wise saying. He said, **"If I have seen further [than certain other men] it is by standing upon the shoulders of giants."**

Ask students: What do you think that means?

Answers will vary. Make mention that we build on other peoples knowledge. Use technology as an analogy, for example, typewriter, word processor, computer, phones' text messaging. Or how the cave man first 'scratched' pictures with the sharpened-stone tool on the walls of his cave home, and now we have pencils and pens to write with on paper.

EXERCISE: Dream about it! Write a couple of paragraphs on what you would like to invent that would be advancing a technology we already have available to us. For example, a phone that if you can click a switch and the phone would create a full-size computer keyboard light image on a table surface that would recognize your taps with your fingers and thumbs, just like an actual computer keyboard.

Hands on activity/Enrichment

Exercise: Create Microgravity

Lesson Activity Objectives: Test how two 'objects' falling at the same rate affect each other (water and the bottle)

Material(s) List:

An empty plastic bottle (Coca Cola liter bottle, for example)

A chair

Some tape

Some water

A large plastic bin (storage type)

Steps

1. Make a small hole (approximately 1/8 inch diameter) in the side of the plastic bottle, approximately ½ inch and 1 inch from the bottom of the bottle.
2. Cover the hole you just made with the tape, so that water cannot escape out of it.

Simulating Microgravity

1. Place the plastic bin on the ground. Place the chair next to it.
2. Fill the bottle ¾ of the way full of water. Tighten the cap onto the bottle so that no water leaks out.
3. Stand up the chair, holding the bottle in your hand. Lay it upon its side, with the hole you drilled in it facing up. Remove the tape, and place your finger over the hole, so that the water cannot escape.
4. Hold the bottle upright, at approximately head height over the plastic bin. Remove your finger from over the hole. Notice what happens with the water inside the bottle.
5. Before all the water runs out, drop the bottle, in the bin. Observe what happens with the water inside the bottle.

Observations:

Until you drop the bottle, the water leaks out of the hole. When the bottle is falling towards the 'earth' at the same rate of the water, (all falling objects fall at the same rate) the water doesn't leak because you just created microgravity!

Applied/Extended Experience – Building Real World Connections

Let's play with Gravity

Exercise: The Impossible Leap:

Steps

1. While standing up, bend over and hold your toes with your hands, keeping your knees slightly bent.
2. Try to jump forward in this position without removing your hands from your toes while you are jumping.
3. Can you do it?

Discussion – Building Connections to Ideas

Observations:

In this position, you can jump backwards from one end of the room to the other, but you won't be able to jump forward! When we jump, we first shift our center of gravity in the direction we want to jump, and then we move our support base in the same direction to regain our balance. When you are holding onto your toes, jumping backwards is not a problem because you can use your heels. But to jump forward, you would have to use your toes, and your fingers are in the way.

Microgravity is not zero gravity (that's another lesson!), but rather objects moving at the same rate, creating a sense of motionless.

The Earth's gravity pulls all objects to it. The sun pulls our Earth because its massive size has a much greater pull but it is moving sideways and that's why Earth is not pulled to the center of it. That's a very good thing!

Performance Tasks – Understanding what was learned

Microgravity can be created in two ways. Because gravitational pull weakens with distance, one way to experience microgravity is to travel away from Earth to a distance where Earth's gravitational pull is weakened to one-millionth of that at the Earth's surface, even though we can't all travel in space, all of us can experience microgravity through a free fall. Microgravity feels like there is no gravity!

Science Standards:

A. National Science Education Standard 1 (Analysis, Inquiry, and Design):
S2.1 - make observations and refine explanations
S2.1b - conduct an experiment to test a hypothesis
S2.1c - design and conduct an experiment to test a hypothesis
S2.2b - design a scientific investigation/controlled experiment
S2.2c - design a simple controlled experiment
S3.2 - interpret data to answer the research question
B. National Science Education Standard 4: The Physical Setting
1. 1.1d - gravity is the force planets in orbit around the Sun
5.1a - the motion of an object is judged with respect to another object
5.1c - an object's motion is the result of all forces acting on it
7. 5.2a - every object exerts a gravitational force on every other object
5.2d - friction is a force that opposes motion

Bibliography

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3. Free Fall. *National Science.* [Online] National Air and Space Museum's Educational Services Department, 1996. [Cited: January 28, 2011.] http://www.nasm.si.edu/exhibitions/gal109/LESSONS/TEXT/FREEFALL.HTM.