The Laws of Motion

Rebekah Murray

"If I have seen further than others, it is by standing upon the shoulders of giants." – Isaac Newton giving credit to the many great scientists who had gone before him

Overview

Everywhere you look, objects are moving. But what makes things move? Some objects move in straight lines, others in circles, and still others in zigzags. People riding roller coasters are in motion, so are kids roller-skating or playing on a playground. Whether they realize it or not, they are following certain laws of motion. Scientists this week we are going to be studying all about motion, so get ready to move!

Background Information

Isaac Newton was a great scientist and mathematician who lived in England in the 1600's. As the story goes, he was one day sitting under an apple tree when an apple fell and hit him on the head. Why, when nothing pushes or pulls an apple, does it fall down to the ground? This was the beginning of Isaac Newton's studies on gravity. Gravity is a force of attraction that keeps objects on the ground.

Isaac Newton was fascinated with why objects move the way that they do. He created three laws that we still use today to explain motion. In his first law of motion (the law of inertia), he discovered that an object at rest wants to stay at rest, unless an unbalanced force pushes or pulls on that object. Also, an object moving in one direction will stay moving in that direction unless an unbalanced force pushes or pulls it in a new direction. For example, a soccer ball will stay sitting on the grass unless someone come and kicks it. A skateboarder will keep rolling in the same direction unless he runs into a sidewalk.

Newton's second law of motion is also easy to understand. You are pushing two people on a swing. One is a baby and the other is a large man. If you want them to go high, which one will you have to push harder? Newton's 2nd law says that an object of greater mass takes more force to accelerate or make move. Force = Mass x Acceleration

In baseball, when a batter hits a ball, the ball goes flying and the bat may do a few different things. It stops moving forward, it may vibrate, and it may even break. Newton's 3rd law states that every action has an equal reaction. Whenever an object pushes another object, it gets pushed back too.

Friction is the idea that objects in motion rub against things, eventually causing them to stop. Friction can prevent an object from moving or can make a moving object slow down.

Main Ideas

- Isaac Newton was a great scientist who studied motion and gravity.
- Gravity is a force of attraction that keeps objects on the ground.
- His first law of motion (the law of inertia) states that an object at rest wants to stay at rest, unless an unbalanced force pushes or pulls on that object.
- His second law says that an object of greater mass takes more force to accelerate.
- Newton's 3rd law states that whenever an object pushes another object, it gets pushed back too.
- Friction is the idea that objects in motion rub against things, eventually causing them to stop.

Materials Needed

- *What is Friction?* By Lisa Trumbauer
- Balls
- String
- Popsicle Sticks
- Small Plastic Cups (used in 2 activities)
- Playing Cards
- Pennies
- Rope
- Finger Pool Board
- Checkers

Preparation

1. Read “Background Information” to become more familiar with the properties of static electricity.
2. Read through *What is Friction?* By Lisa Trumbauer. Prepare questions that you can ask along the way.
3. Make sure that you have all the supplies that you will need for each day’s experiment.

Opening

Isaac Newton was a great scientist and mathematician who lived in England in the 1600’s. As the story goes, he was one day sitting under an apple tree when an apple fell and hit him on the head. Why, when nothing pushes or pulls an apple, does it fall down to the ground? This was the beginning of Isaac Newton’s studies on gravity. Gravity is a force of attraction that keeps objects on the ground.

Did you know that in outer space, there is no gravity. Have you ever seen pictures of astronauts floating around? There is no gravity to keep them down so they can fly. This sounds fun, but it can also be tricky. Imagine trying to eat and all your food floats off your plate in different directions.

Gravity Toy

Today, we are going to make a toy that uses gravity to work. **Have students get into partners. Working together, have them place a string through one of the holes in the ball and out through another hole. Then tie a knot to secure the ball on one end of the string. Have the other partner tape a cup onto one end of the Popsicle stick. Then knot the other end of the string around the Popsicle stick. Have partners take turns trying to swing the ball up and then catch it in the cup.** How does gravity make this toy work? Is it difficult? Do you know that astronauts tried to use this exact same toy in outer space? Would it be harder or easier to use this toy in outer space?

(Note: Please do not allow the students to take these toys home. Save the balls and cups for the next group.)

Introduce Newton’s 1st Law of Motion - His first law of motion (the law of inertia) states that an object at rest wants to stay at rest, unless an unbalanced force pushes or pulls on that object. Demonstrate with a ball. This ball will stay still unless a force pushes or pulls it. You can push it by

throwing it, kicking it, blowing on it, etc. Objects prefer to stay where they are (at rest). Lets demonstrate this.

Objects at Rest Experiments

1) **The Card / Penny / Cup Trick – Give students a plastic cup, a playing card and a penny. Have them place the penny on the card and the card on the cup. Quickly pull the card out from under the penny. If you pull it quickly enough, the penny will momentarily stay in place instead of moving with the card. However, it only stays in place for a moment before the force of gravity makes the penny drop into the cup. Allow students to try this trick several times on their own.**
2) **Coin on the Shoulder Trick – Have students balance a coin on their shoulder. Have them pull their shoulder away quickly. Instead of going with their shoulder, the coin will prefer to stay put. This will only last for a moment before gravity forces the coin to drop. See if students can use that brief moment to catch the coin before it falls to the ground.**

Read *What is Friction?* By Lisa Trumbauer.

Introduce Newton's 2nd Law of Motion – Newton's second law of motion is also easy to understand. You are pushing two people on a swing. One is a baby and the other is a large man. If you want them to go high, which one will you have to push harder? Newton's 2nd law says that an object of greater mass takes more force to accelerate or make move. Force = Mass x Acceleration

Have a volunteer stand up beside you. Select another volunteer to try to pull that student over. Then have the same volunteer try to pull the teacher over. Does it take more force to pull a smaller or a larger person?

Tug of War

Allow different pairs of students to compete against each other in tug of war. What happens if one team were to suddenly let go of the rope? To move a bigger, stronger team, do you have to pull harder?

Introduce Newton's 3rd Law of Motion – In baseball, when a batter hits a ball, the ball goes flying and the bat may do a few different things. It stops moving forward, it may vibrate, and it may even break. Newton's 3rd law states that every action has an equal reaction. Whenever an object

pushes another object, it gets pushed back too just in the opposite direction.

Finger Pool

Use the finger boards provided. Have students play in pairs. Each finger board needs 1 red checker, 3 black, and 3 white. Place the black checkers in a triangle in the center of the board. Place the white checkers around them to form a larger triangle. Put the red checker anywhere outside the red line. The first player flicks the red checker with his or her finger. After each shot, it is the next player's turn. They should return the red checker to anywhere outside the red line and proceed with their turn. The goal is to be the first player to knock all your colored checkers into one of the four corners.

When the red checker pushes into the resting checkers, you are demonstrating Newton's 1st law of motion. When you change how soft or hard you flick the checker in order to knock it into the corner, you are demonstrating Newton's 2nd Law of Motion. When the checkers hit and bounce off of each other, you are demonstrating Newton's 3rd Law of Motion. Friction from the checkers rubbing against the board is what makes the checkers slow down to a stop. Way to use Newton's laws!!!

Further Exploration

Further Exploration of Gravity

If you drop a baseball and a ball of paper to the ground at the same time, which one will hit the ground first? If you drop two different sized balls, will the larger or smaller hit the ground first? Have students make their predictions. The instructor should stand up on a chair and release the balls at the same time. Try this a few times. Which one hit the ground first? A scientist by the name of Galileo is the first known person to try this experiment. He dropped two different sized balls off the Leaning Tower of Pisa. Surprisingly, both balls hit the ground at exactly the same time. If you released them at the same time, you should get the same result. Why doesn't the smaller object hit the ground first, since it is easier to accelerate smaller objects? The force of gravity pulls more on larger objects and less on smaller objects. If acceleration = force /mass, the larger ball has more mass, but also more force pulling it down. Therefore, they have the same acceleration.

Motion Quiz

1. When you hit a baseball with a bat, are you using a push or a pull?
2. When you open a refrigerator door, are you using a push or a pull?
3. At the grocery store, is it easier to push an empty cart or one filled with groceries?
4. Does a carpet create a little bit of friction or a lot of friction? Does a playground slide create a little bit of friction or a lot of friction?
5. When you jump up on a trampoline, how come you always come back down? What would happen if you jumped on a trampoline in outer space?

Newton's Laws on the Playground

1st Law – Push a friend on a swing. The force of your push made an object at rest start moving.
2nd Law – Push a friend down the slide. What happens when you push them gently? What happens when you push them hard? Push two friends on a swing. Give them both equal pushes. Does the smaller or larger person go higher?
3rd Law – Go up and down on a seesaw or teeter-totter with a friend. How does a seesaw work? What happens when you run into someone on the playground?

Motion in Outer Space

You could also check online. There are videos of astronauts performing some of these same experiments in outer space. How does little to no gravity effect the results of the experiment?

Wrap Up

- Have students play finger pool. Come back together as a group and discuss how this game demonstrates all three of Newton's Laws.
- Try Galileo's ball dropping experiment. Which ball hits the ground first?
- Give students the Motion Quiz.
- Take students outside to a playground. Have them brainstorm how they use Newton's laws every day on the playground.
- Have students explain Newton's three laws to a friend.

Signs of Success

The student will…

- Demonstrate engagement and curiosity by performing the laws of motion experiments.
- Describe what they have seen or done, explain what they still want to try, and make predictions for outcomes for new ideas.
- Come up with motion experiments of their own that they would like to try.
- Demonstrate to a friend Newton's 3 Laws on the playground.

Other Books to Explore

Stop That Ball! By Mike McClintock
Irma The flying Bowling Ball by Tom Ross
Little Pig's Bouncy Ball by Alan Baron
The Science Book of Gravity by Neil Ardley
Forces Around Us by Sally Hewitt
Gravity by Susan Canizares and Daniel Moreton
Real Stuck, Way Up by Benette W. Tiffault
Rolling Along with Goldilocks and the Three Bears by Cindy
Meyers Forces and Motion by Angela Royston
Find Out About Pushes and Pulls by Terry Jennings
Wheels by Annie Cobb
Push It or Pull It? by Rozanne Lanczak Williams
Mama Zooms by Jane Cowen-Fletcher
Wheels by Susan Canizares and Daniel Moreton
Push or Pull by Susan Canizares and Betsey Chessen

Pennsylvania Educational Standards

Reading 1.2.3 A, D, E
1.6.3 A, B
1.8.3 A, B

NRC National Science Educational Standards
Content Standard A: Science as Inquiry
Content Standard B: Physical Science

AAAS Benchmarks for Science Literacy
12A Values and Attitudes
12D Communication Skills

Sample Schedule For Making It A Week Long Unit

Day 1:
Introduce Isaac Newton and the concept of gravity.
Construct the gravity toys.
Let the students play with them for the remainder of class.

Day 2:
Introduce Newton's 1st Law of Motion.
Perform the two Objects at Rest Experiments.
Optional: Check out videos of astronauts performing motion experiments in outer space.

Day 3:
Read *What is Friction?* By Lisa Trumbauer.
Introduce Newton's 2nd Law of Motion.
Tug of War

Day 4:
Introduce Newton's 3rd Law of Motion.
Play Finger Pool.
Come back together to discuss the results.

Day 5:
Galileo's Experiment
Motion Quiz
Take students outside for Newton's Laws on the Playground