Sparking Discovery in the Classroom

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Force & Motion

Teacher Resource Guide

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Movement is happening all around us. So much so, that we may not take much notice of it. It can be interesting then, to begin a unit on force and motion by simply stopping and taking note of all the things in the universe that move around us.

Motion Meditation

Have students sit quietly and listen to your voice as you lead them through this motion meditation. Have them listen to the world around them and visualize the movement you are describing. They can close their eyes if it helps them to focus.

We are sitting on a planet that at this moment is spinning around its axis and moving around the sun. We do not feel this movement, but we recognize it as we pass through the day into the night and back into day and as we watch our world change with each passing season. This is movement. As we sit here, we may notice a slight flutter in the air that is moving around us. We might hear movement in the hallways outside the door or out on the playground. We might hear cars rushing past us or airplanes overhead. If we were outside, we might hear animals moving – scurrying squirrels, flapping bird's wings, even their voices singing. All evidence of movement happening. Now turn your attention to the ground beneath us, for movement is happening there too. Animals burrow into the earth and move beneath the surface. Water moves too, whether in manmade pipes or natural rivers. Sewers flow beneath our feet as do subway cars. There is movement in our own bodies. What moves here? Our breakfast moves through our bodies as it is digested. Blood pumps through our arteries and veins. Our eyes flutters, our fingers move, a muscle spasms. Movement. Now imagine the air around us. Hot and cold temperature variations keep the air moving. In that air there are insects flying, hawks soaring, leaves fluttering, rain and snow falling. As we travel high up through the air we can see clouds moving and changing shape. We can see weather fronts moving in or departing. And way up in the sky we can see the moon and stars – movement in the outer reaches of our universe. We are surrounded by things and systems in motion.

Brainstorm

Ask students to brainstorm a list of all the things they can think of that move. Talk about what some of these movements look like and how they happen. Through the brainstorm alone, students may begin to understand that movement happens only when a force acts on it.

Exploring Movement with Toys

Supplies: A collection of toys that use pushes and pulls to work such as balls, spinning tops, ramp walkers, pull along animals, ball mazes, etc.

Students have lots of prior experience with how things move, but they may not immediately realize it. Providing some toys that use motion to work or asking them to find a toy and mess around with it, can be a fun way to discover the science concepts behind what makes things move.
Ask students to select a toy and play around with it. When they have finished with one toy, they can try another. What can they discover about the way these toys move? What makes the toy go? What makes it stop? Can it move by itself? Can they make it move in different directions? Can they make it move at

different speeds? If they can control the movement, ask them to describe how. What happens if two moving toys collide? You might have students jot down a list of words to describe the movement. Does the toy roll, slide, bounce?

Processing the experience:
Select a few random toys to place at the front of the room. Then ask “What did you notice about these toys? Did they move on their own or did they need you to make them move? What did you do to make them move? Ask “Did you find that you could control the movement of the toy and if so, how?” (Push, pull, redirect, tilt the surface it was moving on, stop it, make it move faster or slower). Help the children make the connection that all of these toys needed a force to act on them to make them move. What was that force? A push or a pull.

To make something move, a force has to act on it. A push or pull are forces that we can use to make things move.

What happens when moving objects collide?

Collision – Transfer of Energy
Supplies: five marbles, two yardsticks, masking tape

Lay two yardsticks on a table parallel to one another with a quarter inch gap between them. Place one marble in the gap at the midway point of the two yardsticks and one marble at the end of the yardsticks. Set the marble at the end of the yardsticks in motion so that it rolls along the gap in the yardstick and collides with the marble in the middle. What happens? Now try two marbles placed in the middle and roll one marble in from the end. What happens when the marbles collide? Try varying the force applied to the marbles and the number and order of marbles. You might also try rolling two marbles from opposite ends of the yardstick at the same time and note what happens when they collide in the middle.

Ninja balls
Supplies: One large playground ball and a smaller, lightweight foam ball.

In the last experience students noticed that the motion energy from one ball could be used to make another ball move. In this activity, students will explore that concept when two balls are dropped together.

Bounce the larger of the two balls and have students note how high the ball bounced. Do the same with the smaller ball. Now place the small ball on top of the larger ball and ask the students to predict what they think will happen when you drop the two balls together at the same time. Drop the two balls. Students will see that the energy from the two bouncing balls is transferred to the smaller ball and the smaller ball bounces higher than either of the two balls alone.

Friction Exploration

Supplies: shoes with leather soles and shoes with rubber soles, socks with rubber grips and socks without rubber grips

Ask the question, “What is everyone wearing that uses friction to help us move?” Shoes.
Rub your shoes against the floor. Look at your neighbor’s shoe soles. How do they compare to your own? How might the friction you experience be different wearing those shoes? Can you think of a situation where you had trouble walking over a surface with your shoes? Have you ever walked across a shiny, polished wood floor or over a patch of ice in the winter with leather soled dress shoes on? What kind of footwear would you prefer to wear if you have to walk over icy sidewalks?

Pass out socks with and without grips. Ask the children to place one of each over their hands and try sliding their hands on the table. Ask them to tell you what they notice. They will likely experience that it is harder to slide the socks with grippers across the surface of the table.

Friction can be helpful, like when we are trying to walk across a slippery surface or even when we are riding our bike over the pavement. The rubber surface of the tires grips and pushes against the pavement and propels us forward.

But sometimes friction slows down a movement when we don’t want it to. In those situations we try to devise ways to decrease the amount of friction. Ask the students if they can think of some examples. Sledding down a hill or moving something heavy across the floor perhaps. A lot of machines have moving parts in them. When the parts move over each other they rub together. Too much friction can cause the machines to overheat or wear out quickly. Too much friction also increases the amount of force and energy needed to make a machine work, making it less efficient. Often we use a lubricant to ease friction, something slippery such as oil that allows the parts to move past each other with less friction. Another invention we use is the ball bearing.

Ball Bearing Activity

Supplies: two screw cap lids that fit one inside the other such as a mayo jar lid and a peanut butter lid, marbles that are a bit taller than the sides of the lid and enough to nearly fill the space inside the smallest lid, a heavy book

Lay the book flat on the table and try to make it spin around its center point a few times. What do you notice? Now place the marbles between the two caps, place the book on top of the caps, and once again try to spin the book. What do you notice? The ball bearings reduce the amount of friction and the book should revolve more times and with less force.

Tennis Ball Pull
Supplies: fifty to one hundred tennis balls, a plastic toboggan, a small board that fits within the sides of the toboggan.

Sit in the empty toboggan and try to pull yourself across the bottom of the sled. Now fill the sled with the tennis balls, place the board on top of the balls and at one end of the sled. Sit on the board and again, try to move across the bottom of the sled. What do you notice? Do the balls make your travel easier?

The Engineering Brainstorm Challenge
During the workshop, students worked alone or with a partner to quickly design a toy or game that moves or has moving parts using any of the forces reviewed—push, pull, friction, gravity, collision. They were allowed to use one sheet of paper, one straw, one elastic band, and either one ball or one disk. They did not have to use all of the materials, but they were asked to use at least two of them. Tape, string, and scissors were also provided. This was a quick challenge and was meant to be a brainstorm. Students were not expected to design a perfect toy, but simply were asked to see what they could come up with in 7 minutes.

Following the 7 minutes, students were asked to share their toy with another person or team. The toy brainstorm is just a quick way to get students designing and working with making things move. Students should have the opportunity to review other students work and discuss their ideas with each other. This is a jumping off point – a perfect way to launch into a longer engineering design process. A brainstorm piques kids interest, gives them a chance to test out some materials and identify what works and what doesn't work the way they anticipated, etc.

Where to go from here:

Up the challenge 1:
Assign each material a cost, such as $1/item. Challenge the students to design the least expensive toy with the highest entertainment value. Lengthen the amount of time students have to work on this challenge, but still keep it relatively short. The goal should be to have students designing a toy that works a little better than in the first challenge, but still has room for improvement. Classmates can anonymously review each other's toys and assign an entertainment value to each one. They can also give suggestions for ways to improve the toy.

Up the challenge 2:
Can students redesign their toy using less expensive materials or fewer materials?

Language and visual arts connections:
Have students consider how they might market their toy. Write a radio announcement or TV commercial, design a newspaper ad, or a promotional poster/brochure.

Develop a sales pitch to present their toy to a manufacturer or set-up a classroom version of the television show, “Shark Tank”.

Other challenge ideas:
Provide students with a long box (such as one used by florist shops when delivering roses). Challenge the students to work with a partner to design an obstacle course inside the box for a ball to move through. Have the students move the ball back and forth to each other without hitting the obstacles. How many different ways can they get the ball to move? Can they change the direction of the ball’s motion?

Allow students to mess around with balls and ramps using marbles and foam insulation or pool noodles as the ramps. Provide them with challenges such as:
Can you build a ramp for your ball to roll down?
How far can you make the ball travel?
Can you make the ball move faster?
Can you make the ball travel more slowly?
Can you make the ball roll from one end of the track and stop in a cup?
Can you make the ball go over a hill? Two hills?
Can you make the ball travel through a loop-de-loop on the track?

Observe where on the track the ball moves faster and slower.

Help students to process their experiences by posing questions such as:
How did you make the ball roll faster?
How did you make the ball roll slower?
Which was the highest, the first hill or the second hill? (The first hill had to be the highest to get the ball going fast enough to go over the second hill)
How did you make the ball go over the hills or around loops?

As a culminating activity and opportunity to assess understanding you might challenge students to draw a picture of a roller coaster they would like to build and ask them to make sure what they draw could actually work.

<u>Resources and extension activities</u>
Gym teacher – share your force and motion unit with your physical fitness teacher. Many of the sports students play in physical education are excellent opportunities for students to explore and think about concepts of force and motion.

Poems are an excellent way for students to experience Force and Motion through an alternative subject matter. In our programs we use a poem from Kwame Alexander’s book, <u>The Crossover</u>, and with younger audiences Kevin Lewis’s <u>The Runaway Pumpkin</u>, but there are many poems that use rhythm and language to express movement. Challenge students to find or to write their own work that does the same.

Resources:

Lower Elementary (K-3) Print Resources:

- *Push and Pull*, Patricia J. Murphy, 2002, Children's Press
- *Everyone Shouted Pull!* Claire Llewellyn, 2004 Picture Window Books
- *Froggy Plays Soccer*, Jonathon London, 2001 Puffin Books
- *Casey at the Bat*, Ernest Thayer, 1997 Puffin Books
- *Roll, Slope, and Slide*, Michael Dahl, 2006 Picture Window Books
- *Pushing and Pulling*, Sue Barraclough, 2006 Raintree
- *The Great Fuzz Frenzy*, Janet Stevens, 2005 HMH Books for Young Readers
- *Roller Coaster*, by Marla Frazee, 2003 HMH Books for Young Readers
- *Galimoto* by Karen Lynn Williams, 1991Harper Collins
- *Forces Make Things Move*, Kimberly Bradley, 2005 Harper Collins
- *Newton and Me*, Lynne Mayer, 2010, Arbordale Publishing
- *Oscar and the Cricket*, Geoff Waring, 2009, Candlewick Press

Upper Elementary (4-6) Print Resources:

- *Isaac Newton and the Laws of Motion* by Andrea Gianopoulos, Graphic Novel, 2007 Capstone Press
- *A Crash Course in Forces and Motion with Max Axion, Super Scientist*, by Emily Sohn, 2007 Capstone Press
- *Forces and Motion: From High Speed Jets and Wind-up Toys,* Tom DeRosa and Carolyn Reeves, Master Books 2009

Online Resources

- NASA STI Program, Toys in Space, 2
    - https://www.youtube.com/watch?v=E9RDlIjgftI
- Top 6 kinetic art objects by MIT scientist and artist, Arthur Ganson
    - https://www.youtube.com/watch?v=R-d7l48-95A
- Joseph's Machines on YouTube
    - https://www.youtube.com/user/allonewordplease