Forces of Nature: *Discussion Guide*

Overview
Why do things move, and why do they move as they do? From hurricanes to bike races, the forces that provide the answers are important to people's lives.

Without force, there is no movement in the world. Natural forces such as gravity not only cause motion but also affect speed and direction. Part of a never-ending balancing act, the battle of forces and opposing counterforces, such as air resistance and friction, account for whether something moves and, if so, how fast. Explore the fascinating world of natural forces and motion with your students.

1. Show the video segment "Universal Gravitation" from *Greatest Discoveries with Bill Nye: Physics* program.

- **Pre-Video Activities:**
  - Show photos of the moon, a satellite, and a rocket, and ask students to explain what they think keeps each in orbit around Earth. Then after showing the video segment, see if students can explain further.
  - Have students create KWL charts showing what they know and what they want to learn about gravity.

- **Discussion:** Review the definition of force as the cause of an object's motion or change in direction, and emphasize the importance of gravity as a force in nature. Based on what the video reveals about the force of gravity, see if students can explain these instances of defying gravity with counterforces:
  - zero gravity in outer space (Answer: astronauts are outside Earth's magnetic field)
  - planes flying (Answer: air pressure under the wings)
  - satellites orbiting and returning to Earth (Answer: speed controlled to affect gravitational pull)

- **Research Project:** Assign students to research a question related to gravity, such as one of the following:
  - How and why is gravity different on other planets and on the moon than on Earth?
  - How does the mass (quantity of matter) of an object affect its gravity?
  - How does the distance between objects affect the force of their gravity?

  Using the example of Earth and the moon, help students to understand that the less mass an object has, the less its gravity is. Likewise, review the principle that the farther apart two objects are from one another the less the gravity is between them. (As a result, the moon, which has a lower mass and some distance from Earth, has

less gravity than Earth. However, Earth is still close enough to the moon to keep it in orbit.)

- **Biography:** Introduce the following famous thinkers and scientists who had a role in explaining the force of gravity. Invite students to read a biography of one of them.
  - Aristotle
  - Galileo
  - Copernicus
  - Newton
  - Einstein

2. Show the video segment "Introduction to Forces and Gravity" from *Physical Science: Forces and Gravity* program. (Access to *unitedstreaming* is required.)

- **Pre-Video Activity:** Invite students to take the following true/false quiz before seeing the video:
  - T F Forces in nature can speed up the motion of objects.
  - T F Forces in nature cannot slow down the speed of objects.
  - T F Forces in nature can change the direction of objects.
  - T F The strength of a force is less important than the direction of the force.

  (Answers: T, F, T, F)

- **Group Demonstration:** After showing the video, list Newton's three laws on the board or overhead projector, and request that students explain them. Then assign a team of students to each law to demonstrate it to the rest of the class, using objects in the classroom.
  1. An object at rest stays at rest and an object in motion stays in motion (inertia) unless a force acts on it.
  2. If a force acts on an object, the object will move.
  3. For every action, there is an equal and opposite reaction.

- **Discussion:** Ask students how each of the following demonstrates one or more of Newton's laws:
  - Water spills out of a full bucket of water when a rock is dropped in it.
  - Balancing dominoes are knocked over.
  - A tether ball keeps going around the pole until the rope is wrapped around it.
  - A child slides down a slide even without pushing off from it.
  - An ice hockey puck slides across the ice and into the net.
  - A balloon shoots out when the air inside is released.
  - A bowling ball knocks over ten pins.
  - The speed of a skydiver changes once a parachute opens.

- **Current Events:** Bring a newspaper to class to see if any news stories show the effect forces of nature have on human lives. One common example is wind. Ask: How do winds, especially hurricane-force winds, affect people? Cite examples of the forces of nature causing damage, as with Hurricane Katrina that devastated New Orleans, and see if students can give scientific reasons why this occurs.

3. Show the video segment "Effects of Forces on Speed" from *The Physics of Motion* program. (Access to *unitedstreaming* is required.)

- **Diagramming:** Have students draw diagrams to show the effect of the following forces on a bicycle: air resistance, friction, gravity, and pressure.

- **Discussion:** Using a photograph or drawing of a bicycle, ask students for a scientific explanation of the following:
  - What propels a cyclist forward? (pressure, power, inertia once started)
  - Why do some cyclists go faster than others? (more pressure, power, lighter)
  - What keeps a biker going at a constant speed? (balanced forces)
  - Why do professional cyclists wear sleek clothing? (to lessen air resistance)
  - What brings cycles to a stop? (friction, air resistance)
  - Why is a cycling track banked on the side? (Introduce students to *centrifugal force*, which pulls objects outward when they are circling around a center.)

  Ask students to draw conclusions about how forces affect speed and direction.

- **Problem-Solving:** Challenge students to design cars so that speed increases with the least force possible. Set up a long track made of sloping plywood planks, and invite students to design three-inch cars to release at the top. Using a stopwatch, compare the cars' times. Beforehand, talk about the influence of gravity and inertia, along with the counterforces of air resistance and friction. Afterward, draw conclusions about why certain cars are faster than others.

- **Analogies:** To explain air resistance, the analogy is made to riding a bike through water. Invite students to create their own analogies to clarify the following: gravity, G-force, friction, counterforce, balanced forces.

- **Scientific Method:** Ask students to investigate the relationship between the strength of a force and its effect. Have them design a simple experiment to test their hypothesis. (For example, students might test how far a scrap of paper moves when one person blows on it versus when three people blow on it.) Students should gather data, test their hypothesis, draw conclusions, and explain their results. In general, they will find that these principles apply:
  - the greater the force, the greater the change in motion
  - the larger the mass, the smaller the effect of a force

- **Cause-Effect Chart:** Have students make a cause-effect chart indicating how the following overcome *inertia*: boat, car, person, kite, rocket, bird. Ask which is easiest to move and which is hardest to move. Explain that the greater the mass, the harder something is to move.

- **Mathematics:** Tell students that the mathematical formula for the effect of force on velocity is force = mass x acceleration. Have them solve mathematical problems using this formula.

4. Show the video segment "Coasting Through Physics" from *Scientific Investigations Physical Science: Investigating Motion, Forces and Energy* program. (Access to *unitedstreaming* is required.)

- **Mathematics:** Explain that speed (velocity) is expressed as distance over time. Invite students to solve time and distance problems such as this: If a car is traveling at 30 miles per hour for the first two hours and then 50 miles per hour for three more hours, how far does it travel? (Answer: 210 miles)

- **Glossary:** Have students define the following terms on flashcards: gravity, velocity, acceleration, friction, Gs, inertia, centripetal force.

- **Discussion:** Ask: How do the forces listed above act on roller coaster passengers? On an aerobatic pilot?

- **Experiment:** Direct students to replicate Newton's experiment with gravity to test if heavier objects drop faster. From a high place have students drop a rock and a cotton ball to see which lands first. Ask why a lighter object would be affected more by air resistance. Discuss why conducting the experiment in a vacuum would change the results.

- **Descriptive Writing:** Encourage students to ride an elevator and describe the physical sensations they experience. Then invite students to explain these sensations in terms of the forces acting upon them.

- **Poster:** Encourage students to create a poster to show one of the principles of motion they have learned.

Academic Standards

This discussion guide addresses the following national standards:

National Science Education Standards
www.nap.edu/readingroom/books/nses/html/

- Motions and forces

Mid-continent Research for Education and Learning (McREL)
http://www.mcrel.org/compendium/browse.asp

- Language Arts
  - Writing: Uses the general skills and strategies of the writing process, uses the stylistic and rhetorical aspects of writing

- Science

- Understands forces and motion:
  - *Level II (Grades 3–5):*
  - Knows that the Earth’s gravity pulls any object toward it without touching it
  - Knows that when a force is applied to an object, the object either speeds up, slows down, or goes in a different direction
  - Knows the relationship between the strength of a force and its effect on an object (e.g., the greater the force, the greater the change in motion; the more massive the object, the smaller the effect of a given force)
  - *Level III (Grades 6–8):*
  - Understands general concepts related to gravitational force (e.g., every object exerts gravitational force on every other object; this force depends on the mass of the objects and their distance from one another; gravitational force is hard to detect unless at least one of the objects, such as the Earth, has a lot of mass)
  - Understands effects of balanced and unbalanced forces on an object’s motion (e.g., if more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude; unbalanced forces such as friction will cause changes in the speed or direction on an object's motion)
  - Knows that an object that is not being subjected to a force will continue to move at a constant speed and in a straight line