

## Guiding Questions Activity 5

- **What is a force? What are Newton's laws of motion?**

**Purpose: To define force and explore Newton's three laws of motion.**

**Note: Earlier we established through experimentation that motion occurs when an object is changing position. We also demonstrated through experimentation that a force is required to start a body in motion, to slow it down or stop it, to change the direction of its motion or to make it move faster. A force is a push or pull on an object.**

**Although motion is one of the most interesting phenomena in the universe that occurs all the time and everywhere, people generally know little about it. Taking everyday occurrences, investigating them step-by-step students will be able to work out a real understanding of motion. As students work their way through various experiments they will discover and be able to describe various scientific facts. Eventually they will determine that they have made some of the same discoveries as Newton.**

**In introducing this topic, I generally tell the following story. As a young girl at the age of 10 I was determined that I would have my own bike. So, with my father's help, we searched for discarded bicycle parts. After collecting wheels, frames, handlebars and a seat, we worked together to build a bike. I was thrilled the first time I got on my bike to take a ride down our gravel road. Everything worked wonderfully until the moment my bicycle chain broke. I suddenly found myself flying over the handlebars of my bike and landing and sliding on my knees across the gravel. My bike lay several feet behind me.**

**I then ask students what they think caused my motion. Not only the motion that carried me over the handlebars but also the motion that carried me sliding across the gravel. What caused me to finally stop? Why did the bike end up lying on its side behind me? What do they think happened to the chain? Where do they think it landed? Which do they think had more mass, the bike, the chain, or me? Eventually lead the conversation to other experiences they might have had or what things in the room are in motion and why. Through discussion and questions, students can discover that motion does not happen by itself but depends on something to make it happen and that the size of the object affects its motion.**

### **Newton's Laws of Motion**

**During the years 1665 to 1666 Isaac Newton spent his time at his family farm escaping the Bubonic plague that was spreading throughout London. It was there that Newton developed the three laws that describe all the states of motion. Many years later the significance of his contribution was expressed by an Apollo astronaut, hurtling toward the moon, when he thanked Newton for making the trip possible.**

#### **Newton's First Law of Motion**

**Aristotle taught that all matter should normally be at rest. He believed that if an object in motion should stop moving it is because no force was present to keep it moving. He believed an unbalanced force had to be present just to keep an object moving. Take away the force, and the object stops moving. This can be easily demonstrated by rolling a cart along the floor. Give the cart a push (unbalanced force) and the cart rolls. When it stops, ask students why it stopped. You might be surprised to hear them give you the same answer taught by Aristotle. It is at this point you would remind them about friction.**

**Friction is what causes the cart to stop. Without friction the cart would continue to roll. Newton believed that without friction an object would continue to move forever. An object resting would stay at rest forever until it was acted upon by an unbalanced force. So a football sitting in the middle of a football field would stay there forever unless some unbalanced force acts upon it such as a player picking it up or kicking it. Newton called this tendency of objects to remain in motion or at rest *inertia*. Earlier we learned that massive objects require a greater unbalanced force to move them than lighter objects. Newton concluded that the more massive an object is the greater inertia it has so the greater the unbalanced force required to move it. Also in order for an object to change its velocity, or accelerate, a force must act upon it. A good example to give at this point is riding on a bus. Students will feel the effects of inertia when standing on a stopped bus. When the bus begins to move forward they will fall backwards. If the bus suddenly stops, they would fall forward. Even though the bus stops the student keeps moving.**

**Newton's first law of motion states: *An object at rest will remain at rest and an object in motion will remain in motion at constant velocity unless acted upon by an unbalanced force.***

### **Newton's Second Law of Motion**

**Newton's second law describes how force and acceleration are related. If it's baseball season you can discuss how fast a pitcher pitches a ball or how fast the ball is moving once it is struck by the batter's bat. Softballs are larger than baseballs. If a batter using the same bat hits each ball with the same force will they both move at the same speed? Will they both travel**

the same distance? If it's warm outside, take your students out on the playground and try this.

Newton's second law states: *Acceleration of an object increases as the amount of force causing the acceleration increases. The larger the mass of the object, the larger the force needed to produce acceleration.*

$$\text{Force} = \text{mass} \times \text{acceleration}$$

The unit for force is the newton. One newton is the force needed to cause a one kilogram mass to be accelerated at the rate of one meter per second each second.

### Newton's Third Law of Motion

Watching an old movie with Stan Laurel and Oliver Hardy I couldn't help but be reminded of Newton's third law. In Stan's attempt to get off a row boat he was put through a series of comic struggles because whenever he tried to step from the boat onto the dock the boat moved backwards knocking him down into the water. As he steps out from the boat, he pushes against the boat. The boat in turn pushes back against him. The two pushes make a pair of equal and opposite forces. Unfortunately he ends up misjudging the distance and into the water he goes!

Newton's third law states: *When a force is exerted on an object, the object exerts an equal force in the opposite direction. The two forces are called action and reaction forces. The reaction force is equal to the action force and acts in the opposite direction.*

One classic example used to illustrate this law is the motion of walking. As you walk your feet push against the floor. At the same time the floor pushes with an equal but opposite force against your feet. You move forward.

**In review, we see that Newton's three laws describe all aspects of an objects motion. The first law tells us that forces are necessary to change the motion of an object. The second law describes how force and acceleration are related to mass and inertia. His third law explains how forces always act in pairs.**

**Looking for more bonus points? Try this thought question. How will Newton's Laws apply to SuitSat2 as she starts her journey away from the ISS?**

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