Newton’s Laws of Motion

Grade Level: Middle School

Physics

Objectives:

Students will:
-Using information from class lecture, students will see Newton’s Laws in action.
-Use Newton's Laws during building and launching of bottle rockets.
-Calculate velocity and altitude of rocket launches using formulas.

Materials:

-long balloons
-straws
-10 feet of string or fishing line
-tape
-2 plastic soda bottles
-cork
-aluminum foil
-baking soda
-vinegar

Procedure:

Newton's Laws

A. Newton’s First law states that:
Every object continues in its state of rest, or of uniform velocity in a straight line, as long as no net force acts on it.

B. Newton’s Second law states that:
The acceleration of an object is directly proportional to the net force acting on it, and is inversely proportional to its mass. The direction of the acceleration is in the direction of the net force acting on the object.

$\Sigma F = ma$ (where F and a are both vectors)

C. Newton's Third law states that:

Whenever one object exerts a force on a second object, the second exerts an equal force in the opposite direction on the first.

$F_{ab} = -F_{ba}$ (where "ab" and "ba" are subscripts)

Background Knowledge:

Inform the students that the way rockets are propelled is that they use their exhaust to "push off of." In this manner, they can be propelled in space even without atmosphere or a stable platform as a base.

Also, allow the students time to weigh each of their bottle rockets with all equipment attached prior to launch and after launch. Also, the time taken and distance traveled must be recorded.

First Experiment:

Attach one end of the string to a wall. Inflate the balloon and tape the straw or tubing to it. Place the other end of the string through the straw and hold the string tight. Release the balloon and observe the result. Modify the design to achieve maximum propulsion. Using a stopwatch and meter stick, estimate the velocity of your rocket.

Second Experiment:

Pour about 1 cup of vinegar into a 2 liter soda bottle. Fold a small piece of foil into a canoe-shaped trough, small enough to fit through the bottle opening, but large enough to hold about 3 tablespoons of baking soda. Lay the bottle on its side in an outdoor location. With the stopper in one hand, slide the foil boat with baking soda into the bottle and quickly plug the bottle. Shake the bottle to mix the soda and vinegar. When the pressure becomes great enough, the stopper will be ejected in one direction and the bottle will go in the other.

Assessment:

Have students calculate the Force exerted by the balloon using the F = ma formula. Ask them if the results make sense with the background knowledge that they have been given.

-----Concept Questions to insure understanding-----

1. Newton's First Law

   Explain why a person is likely to "fall" forward when standing on a bus that comes to a sudden stop?

Explanation: The person continues in his/her state of forward motion with the same velocity as the velocity of the bus decreases.

2. Newton's Third Law

   Explain why a person will experience a pain in their wrist/ arm when they fall to the ground suddenly.

Explanation: The reason the person will be injured by the fall is because when they hit the ground, the ground is actually exerting an equal force back onto their body. Because of this, the ground is actually inflicting the pain on the person.