**The Lesson – Newton’s Three Laws of Motion**

1. Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it. (This is basically Galileo’s concept of “inertia”, and is often referred to as the “Law of Inertia”.)
2. The acceleration (a) of an object is proportional to the force (F) applied and inversely proportional to the mass (m) of the object: F = ma. (Mass is not the same as weight, but for our discussion we can use weight instead of mass if it confuses your student.)
3. For every action there is an equal and opposite reaction.

In other words, a stationary object will stay that way unless an external force is applied to it. Also, an object in motion will continue at a constant velocity and in a straight line unless an external force is applied.

The acceleration (or deceleration) is the amount of force applied relative to the mass of the object. The change in velocity (speed) is the amount of force applied over time. (This is why a rocket does not immediately go off the launch pad to orbital speed in 4.8 seconds or less. And it is also why your car takes as long as it does to reach highway speeds, or to come to a stop.)

How do we demonstrate these laws?

To demonstrate the first law, place a rubber ball, softball, baseball, etc on the floor. It does not move. The first law in action. Now have your student move several feet away from the ball and roll it to the student. Feel the ball ‘hit’ your hands? That is the force being taken away from the ball to make it stop. Now have your student roll the ball back to you. The motion to roll the ball applies force to it to cause it to move. You can also demonstrate this by playing ping-pong, kickball, soccer, or billiards.

To demonstrate the second law, use a ball that you can kick. I prefer a soccer ball. Kick the ball easily. It accelerates, although not much. Now kick it really hard! The amount of time that the force is applied is the same – the one kick. But the amount of force is very different and so is the resulting acceleration.

Now let’s apply acceleration over time to see what happens.

**Parts List**

1 roll of ¾ inch masking tape

1 roll of 1½ inch masking tape

1 3 x 5 card (or more if you wear it out!)

1 schedule 40 tee, 1¼x1¼x1” (ask the folks in plumbing) $1.38

2 schedule 40 pipes, 1¼” diameter 5 feet long $3.20 each

1 vacuum cleaner with a hose or a Shop-Vac

Play-Doh

**Instructions**

Cut one of the pipes into a 2 foot and 3 foot length, so that you have three pipes: 2 feet, 3 feet, and 5 feet long.

Make a ball of Play-Doh just barely small enough to fit inside the pipe and roll down the pipe.

Wrap enough layers of the ¾” masking tape around the very end of the vacuum cleaner hose to give it a diameter of just under 1 inch.

Insert the end of the vacuum cleaner hose into the 1” opening of the tee, but only far enough for about half of the masking tape is inside the tee. Use the 1½” masking tape to secure the hose into the tee and to create a tight seal.

Insert the 2 foot length of pipe into the tee.

Turn on the vacuum cleaner.

Place the 3 x 5 card over the open end of the tee, so that the only opening is the end of the pipe.

Point the open end of the pipe DOWN so that it is at a 45º angle.

Insert the ball of Play-Doh into the open end of the pipe. It will travel up the pipe and out the other end of the tee, pushing past the 3 x 5 card and at least 20 feet through the air.

Replace the 2 foot pipe with the 3 foot pipe. Repeat the process by placing the card over the end of the tee and inserting the ball.

Replace the 3 foot pipe with the 5 foot pipe. Repeat the process.

Who says learning and science aren’t fun!

**Follow-Up Questions**

Which pipe produced the longest flight? Why?

Which pipe took the longest time for the ball to move from one end to the other?

Does the amount and velocity of suction from the vacuum cleaner have any effect on the flight of the ball? Why?

Why does the ball slow down and fall to the ground?

**Resources**

http://www.instructables.com/id/Make-a-Vacuum-cleaner-Bazooka/

http://www.instructables.com

An interesting resource for fun things to do, some of which demonstrate scientific principles.

Vacuum Bazookas, Electric Rainbow Jelly, and 27 Other Saturday Science Projects. Neil A Downie ISBN: 9780691009865

**Civil Air Patrol**, Aerospace Education Member Resources

http://www.capmembers.com/aerospace\_education/

Resources for over 20 hands-on science lessons, as well as resources for model rocketry, robotics, satellite test kit software to experiment with orbits in space, software for designing and building model airplanes, and much more!

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