Newton's Second Law of Motion

Overview: Newton's Second Law of Motion is for objects experiencing unbalanced forces. The first law, usually called the law of inertia, says that if all the forces acting on an object are balanced then the object is in equilibrium and does not accelerate. The object can either be at rest or in motion, but not accelerating (the object can be at a constant speed and traveling in a straight line). Objects not in equilibrium experience unbalanced forces, which causes them to accelerate. Acceleration is a change in speed, direction, or both.

What to Learn: Students will learn how to calculate the net force and acceleration of an object. They will learn that acceleration of an object produced by the net force (the vector sum of all forces) is directly proportional to the magnitude of the net force, in the same direction as the net force, and inversely proportional to the mass of the object.

Materials

- friends
- wagon
- rocks
- stopwatch
- measuring tape

Lab Time

1. Now we're going to experiment with Newton's Second Law that deals with force, mass, and acceleration. Start with an empty wagon.
2. Pull it and try to get it to go as fast as it can, as fast as you can. In other words, get it to accelerate.
3. Now add weight. Put something in the wagon that weighs at least 50 lbs. or so (a nice, solid kid comes to mind).
4. Pull it again and get it to go as fast as it can as fast as you can.
5. Add more weight and do it again.
6. Keep adding weight until you have a very difficult time getting it to accelerate.

So what happened here? Force equals mass x acceleration. The mass was the wagon. The force was you pulling. The acceleration was how fast you could get it to speed up. The heavier you got the wagon (the more mass (m) there was) the harder (the more force (f)) you had to pull to get the wagon to move (to accelerate (a)), or F = ma.

An object that has a lot of momentum is going to take a lot of effort to stop. Momentum refers to the quantity of motion that an object has. It's defined as mass in motion. If an object is moving, then it has momentum. How much momentum it has is calculated by this equation: momentum (p) = mass (m) x velocity (v), or p = m v.

Note for the table below: Try using the standard metric system. The conversion from the weight you measure on a scale (measured in pounds) to a quantity of mass in kg is this:

1 pound = 0.4365 kg
So a 100-lb kid has a mass of 45.36 kg.

7. Now let's fill out the data table. First, weigh the kids you are going to use as weight in the wagon. Record this in your data table.
8. With chalk or string, mark off three lines. The first is the start line, where the wagon is going to start from rest. The second is about 2 meters (6 ½ feet) away, and when the wagon crosses this line it should be at constant speed. The third is the finish line, a distance of about 7 meters (about 23 feet) from the middle line. Make sure the course is on a long, straight-and-level path. We want the kids to be at the same speed when they cross the start and finish line.
9. Get out your timer. Load the wagon with kids.
10. Start pulling the wagon at the start line at the same time you start the timer.
11. Pull the kids and reach a constant speed when you cross the middle line. As you cross it, look at your timer (but don't stop timing). Record this time as your time to accelerate.
12. Continue timing until you cross the finish line. Stop timing and record the time.

Now you give it a try:

Newton's Second Law of Momentum Data Table

Mass of Kids in Wagon *(kg)*	**Total Time** *(seconds)*	**Time to Accelerate** *(seconds)*	**Time at Constant Speed** *(seconds)*

Reading

Newton's Second Law tells us what's going to happen when forces don't balance (and in the real world, they usually don't). This law states that unbalanced forces cause objects to accelerate in direct proportion to the net force, and inversely proportional to the mass.

The second law is also referred to when discussing momentum. The second law defines a force to be equal to the change in momentum with a change in time. Momentum (p) is the mass (m) of an object multiplied by is velocity (v). If your mass is 100 kg, and you're travelling in a straight line at 10 m/s, then your momentum is 1,000 kg m/s.

Exercises Answer the questions below:

1. What concept does Newton's Second Law of Motion deal with?

2. What is momentum?

Answers to Exercises: Newton's Second Law of Motion

1. What concept does Newton's Second Law of Motion deal with? (force, mass, and acceleration)
2. What is momentum? (mass times velocity, or mv)