Force and Motion: Newton's Laws

TOPICS AND FILES

Mechanics Topics

Newton's first law, $F_{\text{net}} = 0$

Newton's second law, constant mass

Capstone Files

14 Newton's 1st Law.cap

15A Newton's 2nd Law 1.cap

EQUIPMENT LIST

Qty	Items	Part Numbers
1	PASCO Interface (for one sensor)	
1	Motion Sensor	CI-6742
1	1.2 m Dynamics Track	ME-9435A
1	Dynamics Cart	ME-9430
1	Fan Accessory	ME-9491
1	Friction Block (ME-9807)	part of ME-9435A
1	Mass and Hanger Set	ME-9348
1	Balance	SE-8723
1	Super Pulley with Clamp	ME-9448
1 m	String	SE-8050

INTRODUCTION

This lab has two parts.

The purpose of Experiment 1 is to investigate the meaning of inertia and experimentally determine Newton's first law of motion: *An object at rest stays at rest unless acted on by an external force. An object in motion continues to travel with constant velocity unless acted on by external force.* You will be asked to examine the motion of different objects as they experience different applied forces. Use a motion sensor to measure the motion of a cart as it experiences different applied force. Use *Capstone* to record the motion.

In Experiment 2, you will be asked to determine what happens to the acceleration of the cart when the net force is increased and the mass stays constant. *The direction of the acceleration of an object is in the direction of the net external force acting on it.* The acceleration is proportional to the net external force $\overrightarrow{F}_{\text{net}}$ in according with the equation below.

$$\Sigma \overrightarrow{F}_{\text{net}} = m \cdot \overrightarrow{a} \tag{1}$$

This is one of the most important equations in physics, also known as *Newton's second law of motion*. Newton's second law describes the behavior of everything that changes its motion due to a net force—from the trajectory of a baseball to the motion of a planet. Use a motion sensor to measure the motion of a cart as it experiences different applied force. Use *Capstone* to record the motion.

BACKGROUND

After doing experiments with balls rolling down ramps, Galileo proposed that an object in motion would continue in motion forever if the floor it rolls on were perfectly smooth and continued to infinity. Galileo used the word *inertia* as the label for this tendency of an object to continue its state of motion.

Isaac Newton developed Galileo's ideas. What condition must exist for an object to maintain its state of motion? Newton said that an object at rest tends to stay at rest and an object in motion tends to stay in motion if there is no net force acting on the object. In other words, if the net force on an object is zero, its acceleration (change in motion) is also zero. The second law of motion deals with what happens when a net force does act.

$$\vec{a} = \frac{\vec{F}_{\text{net}}}{m} \tag{2}$$

As long as a net force acts, the velocity of an object changes—in other words, it accelerates. If more force is applied, the greater force produces a greater acceleration. Twice the force produces twice the acceleration. Often, several forces act on an object simultaneously. In such cases, it is the net force, or the vector sum of all the forces acting, that is important. Newton's second law states that the acceleration is proportional to the net force acting on the object.

$$\vec{a} \propto \vec{F}_{\text{net}} \tag{3}$$

Newton's second law also states that the acceleration is inversely proportional to the mass.

$$\vec{a} \propto \frac{1}{m} \tag{4}$$

