Intro to Dynamics - Newton's Laws

This is where the ***real*** physics begins. Physics is more than equations and math problems -- it is the laws of the universe and, most importantly, ***understanding*** these laws. The laws, of course, determine how everything works.

The first of these laws we will study were developed by Sir Isaac Newton while he camped out on a farm having fled the London plague of 1665. An interesting thing about all of it is that he didn’t publish them until 1687. Wonder why? Anyway, twenty-two years later in 1687 he finally got around to publishing them in his book, *Philosophiaie* *Naturalis Principia Mathematica* (*Mathematical Principles of Natural Philosophy*) which is usually known as the *Principia*. It was written in Latin and wasn’t translated into English until 1729. Other trivia bits on the thing? Okay. The *Principia* is perhaps the greatest scientific work ever written. In it Newton set out how the universe operates. He explained how the planets orbit the sun, how the moon orbits the earth, and how objects behave on earth. It basically founded the science of physics.

So let us get into the physics.

***Inertia:*** Inertia is an important property of matter.

***Inertia ≡ property of matter that resists changes in its motion.***

Basically, because of inertia, objects want to maintain whatever motion they have. This was described initially by Galileo, later Sir Isaac Newton formulated it into one of his basic laws of motion.

Inertia is proportional to mass. The more mass something has, the more inertia it has.

***Mass ≡ measurement of inertia***

The unit for mass is the kilogram (kg). Mass is also defined as the amount of matter something has. Mass is different than weight, which is the gravitational force of attraction between the earth and an object.

***More important definitions:***

* + ***Force*** ≡ ***push or pull***

## Contact Force ≡ physical contact exists between the object and source of the force

* + Field Forces ≡ No contact exists between the source of the force and the body being acted upon: gravity, magnetic force, etc.
  + Friction≡ A force that resists the motion between two objects in contact with one another

The First Law: Newton’s First Law: An object at rest remains at rest, and an object in motion remains in motion with constant velocity unless it is acted upon by an outside force.

This law really deals with inertia. It is because of its inertia that matter behaves according to this law. The idea that something would keep moving at a constant velocity for like forever is something that we don’t see happen very often on the earth, because when something is moving, there is almost always an outside force acting on it – usually friction. This is why a ball rolling along a straight section of road will come to a stop all on its own. Friction slows it down and makes it stop.

When the net external force acting on an object is zero, the acceleration on the object is zero and it moves with a constant velocity. Of course if it is at rest, it will remain at rest. (Unless and outside force blah blah blah….)

If  Then  And *v* is constant

***The Second Law:*** Second Law ≡ The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass.

This is usually written as a simple formula, 

More properly, however, it should be thought of as: 

This means that the acceleration of an object is a function of the ***sum of all forces*** acting on it. The sum of these forces is known as the ***net force***.

***Force is a vector!***

The unit for force is the Newton (N) ******

In the USA, the unit for force is the pound (lb). 1 N = 0.225 lb

Newton’s second law is responsible for weight. Weight is a force, the force of gravity acting on something. Using the second law, we see that the weight of an object is:  Here, ***w*** is the weight.

***Weight ≡ force exerted by gravity on an object’s with mass.***

The weight of an object depends on the acceleration of gravity. If the acceleration brought about by gravity changes, then the weight can change. This does not happen with mass - the mass of an object is a constant and has the same value everywhere. If you were to travel to the moon, your weight would be only 1/6 of its value on earth, but your mass would be the same. This is because the gravity on the moon is much smaller than the earth’s gravity.

1. An object has a mass of 10.0 kg, find its weight.



Recall that accelerations change velocities. Therefore, the net force is the thing that causes accelerations.

1. A 450 kg mass is accelerated at 2.5 m/s2. What is the net force causing this acceleration?

*∑ F = ma* 

1. A 2500 kg car is pushed with a net force of 250 N force, what is the acceleration acting on the car?

∑ *F = ma * 



1. Now same problem, same 250 N force and all, but the mass of the car is twice as big, 5000.0 kg. Let's find the acceleration once again.



The acceleration is only one half the value of the first problem.

1. An artillery shell has a mass of 55 kg. The projectile is fired from the piece and has a velocity of 770 m/s when it leaves the barrel. The gun barrel is 1.5 m long. Assuming the force and therefore the acceleration is constant while the projectile is in the barrel, what is the force that acted on the projectile?

Find *a:* 



Find the force:



***The Third Law:***

Third Law ≡ If two objects interact, the force exerted on object 1 by object 2 is equal in magnitude but opposite in direction to the force exerted on object 2 by object 1.

The classic way of saying this is, “For every action there is an equal and opposite reaction”.

Newton’s third law simply says that forces come in pairs. You push on a wall and the wall pushes on you. We call these ***action/reaction force pairs***.