Forces and Newton’s Laws

A **force** is a push or a pull that acts on an object or mass. When an unbalanced force is exerted on an object, the object accelerates in the direction of the force and this acceleration is proportional to the force and inversely proportional to the mass of the object.

Force = (mass)(acceleration) F = ma

Σ Forces = ma (The sum of all the forces = ma)

This is a mathematical statement of Newton’s second law. There are two things that we should notice about Newton’s second law. If there is **a net force** (unbalanced force) acting on an object is must accelerate, and if an object is accelerating, there must be a net force acting upon the object.

The standard unit of force is the Newton (N), and it is equal to 1 kg·m/s2

Mass, or the amount of matter in an object does not change, it is a constant property of the object. A bottle of Coke has a certain mass, a bowling ball has a certain mass.

When an object is acted upon by a large object, like Earth, there is a force of attraction between the object and Earth due to Gravity. This gravitational force is called weight.

Fw = m g

Where g = 9.8 N/kg. This value comes from Newton’s Universal Law of Gravitation

F = G(mE)(mobj)

(RE)2

G is a constant, as is the mass of Earth and the Radius of Earth. When we take G(mE)/(Re)2 = 9.8 N/kg which we call “little g”. This is the gravitational field constant. If we move to a different planet, or the moon, there will be a different value for little g, but it would be a constant for that planet. Moving objects from Earth to some other planet would change the weight of the object, but never its mass.

When an object sits on the surface of Earth, the attractive force due to gravity pulls the object down, keeping it on the surface. There must also be some force that the surface puts on the object which will keep the object from moving into the floor. This supportive force from a surface is called the **Normal** force. The normal fore ***Always acts perpendicular to the surface where our object is located.***

In order to begin studying force, we must first be able to identify all the forces that are acting on an object in a particular situation. To do this, physicists use a tool called a **Free body diagram**, which is sketch that we create that identifies and labels all the forces.

To draw a free body diagram, first sketch a picture of the situation, then identify any points where the universe touches the object. At each of these places there must be a force. Then identify any forces that act at a distance to pull the object. The only one of these we know so far is Gravity.



Take this picture of a person pulling a sled with a dog on it. If we want to identify all the forces acting on the sled/dog system, we can draw a circle around the sled/dog and then everywhere the universe touches that circle there must be a force



Here we have tension in the rope applying a force up and too the right. We have the Normal force of the ground onto the sled, and some friction. Earth applies a downward force = mg, the weight of the sled/dog.

Felicia the dancer has a mass of 45.0 kg. What is her weight on Earth? What is Felicia’s mass on Jupiter, where g = 25.0 m/s2? What is her weight on Jupiter?

Butch is a quarterback who is running and collides with a defensive lineman. Butch is brought to a stop with an acceleration of – 20.0 m/s2. What force does Butch experience? What force does the defensive lineman experience?

One kg weights about 2.2 pounds. Using this info determine your mass in kg. Determine your weight in Newtons on Earth.