Forces

So class we have pretty much covered the topic of how things move but now we are looking to answer a more fundamental question of " Why do things move the way they do" or "why do they even move at all".

Well the truth is, this simple concept had baffled great thinkers for thousands of years and the answer to this question also explains the origins of physics.

Lets go back to the times of the Greek philosopher Aristotle (384–322 BCE).

He was a great thinker of his time and he came up with some assumptions to the questions relating motion and they are as follows:

- **A body, not acted on by any force (**Push or Pull**), remains at absolute rest. Nothing moves unless you push it**. [It is moved by a mover]
- **The most Natural state is Rest.** (Makes sense doesn't it if you push a rock or even something round it will still come to rest)
- **Force is proportional to the velocity. F=mv**
- **Heavy objects fall faster than light objects.**
- **There is no such thing as a vacuum.**

His theories persisted for thousands of years until they were finally tested and ALL of them were subsequently DISPROVED.

It was actually Galileo Galilei the Italian physicist, mathematician, astronomer, and philosopher that tested these assumptions and came up with the concrete theories.

Galileo knew that objects come to rest but he realized it was for entirely different reasons (**Friction and other opposing forces**). In other words if you can make a surface smoother and reduce friction, a moving object will continue to travel for longer before coming to a stop.

Now imagine that if you move an object along a frictionless surface what would happen? Well the object in motion will continue to move with the same velocity without slowing down.

Therefore to Galileo the **Natural State of Motion is Constant Velocity Motion.**

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Now Sir Isaac Newton, who was born 100 years after Galileo expanded on his theories to create his three laws of motion which state:

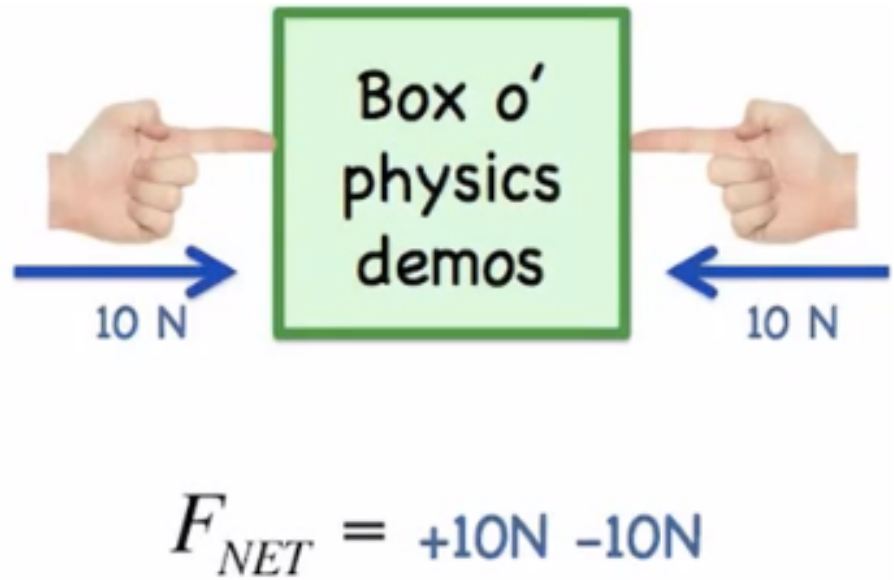
NEWTON'S FIRST LAW

- An object at rest tends to stay at rest, and an object in motion tends to stay in uniform motion, with a constant speed in the same direction <u>unless acted upon by an external unbalanced force.</u>

OR

- If the $F_{net} = \Sigma F = 0$. Then an object at rest stays at rest and an object in motion, moves at constant velocity.

$$F_{NET} = F_1 + F_2 + F_3 + \cdots + F_n$$



SO IN ORDER TO CHANGE AN OBJECTS VELOCITY YOU NEED A NON-ZERO NET FORCE ON THE OBJECT.

ASLO THE TENDENCY FOR AN OBJECT TO RESIST CHANGES IN MOTION IS CALLED **INERTIA** AND IT IS A PROPERTY OF MASS.

THE GREATER THE INERTIA THE HARDER IT IS FOR A BODY TO ACCELERATE OR DECELERATE.

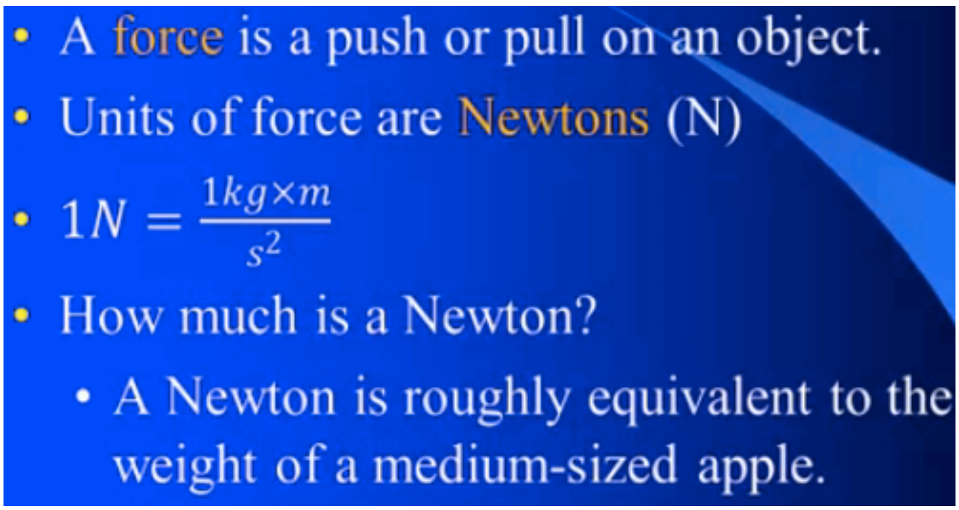
Following on from his first law newton noticed that if you apply a non-zero net force to an object then it in fact accelerates and he also noted that the acceleration is in the same direction as the force. He summarized his finding in the following law:

NEWTON'S SECOND LAW

$\vec{a} = \frac{\vec{F}_{NET}}{m}$ OR $F = m\,a$

THE ACCELERATION IS DUE TO THE FORCE.

THEREFORE THE UNITS FOR FORCE ARE:



Now the last of Newton's laws is the easiest to remember but the hardest to grasp. He said that forces come along in pairs such that if I exert a force on an object then that object also exerts a force on me as well that has the same size but opposite direction. He stated it more beautifully in his Third Law:

NEWTON'S THIRD LAW

If object 1 exerts a force on object 2, then object 2 exerts a force on object 1 with the same size and opposite direction.

$$\vec{F}_{1\text{ on }2} = -\vec{F}_{2\text{ on }1}$$

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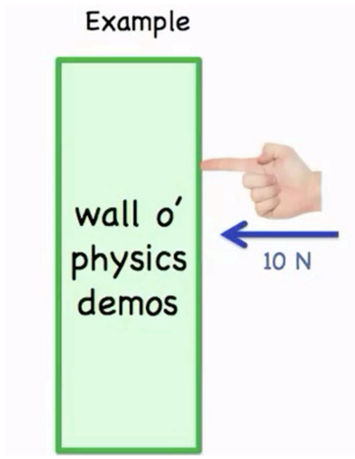

You may be wondering, what are some of the common types of forces that physicists deal with. There are a variety of types of forces and we can categorize them into two broad headings based on whether the force resulted from the contact or non-contact of the two interacting objects:

Contact Forces	**Action-at-a-Distance Forces**
Frictional Force	Gravitational Force
Tension Force	Electrical Force
Normal Force	Magnetic Force
Air Resistance Force	
Applied Force	
Spring Force	

We will now briefly explain each of these types of forces listed above:

Type of Force	**Description of Force**
Applied Force **F_{app}**	An applied force is a force that is applied to an object by a person or another object. If a person is pushing a desk across the room, then there is an applied force acting upon the object. The applied force is the force exerted on the desk by the person.
Gravity Force (also known as Weight) **F_{grav}**	The force of gravity is the force with which the earth, moon, or other massively large object attracts another object towards itself. By definition, this is the weight of the object. All objects upon earth experience a force of gravity that is directed "downward" towards the center of the earth. The force of gravity on earth is always equal to the weight of the object as found by the equation: **$F_{grav} = m * g$** where g = 9.8 N/kg (on Earth) and m = mass (in kg) (Caution: do not confuse weight with mass.)
Normal Force **F_{norm}**	The normal force is the support force exerted upon an object that is in contact with another stable object. For example, if a book is resting upon a surface, then the surface is exerting an upward force upon the book in order to support the weight of the book. On occasions, a normal force is exerted horizontally between two objects that are in contact with each other. For instance, if a person leans against a wall, the wall pushes horizontally on the person.
Friction Force **F_{frict}**	The friction force is the force exerted by a surface as an object moves across it or makes an effort to move across it. There are at least two types of friction force - sliding and static friction. Thought it is not always the case, the friction force often

	opposes the motion of an object. For example, if a book slides across the surface of a desk, then the desk exerts a friction force in the opposite direction of its motion. Friction results from the two surfaces being pressed together closely, causing intermolecular attractive forces between molecules of different surfaces. As such, friction depends upon the nature of the two surfaces and upon the degree to which they are pressed together. The maximum amount of friction force that a surface can exert upon an object can be calculated using the formula below: $F_{frict} = \mu \bullet F_{norm}$
Air Resistance Force **F_{air}**	The air resistance is a special type of frictional force that acts upon objects as they travel through the air. The force of air resistance is often observed to oppose the motion of an object. This force will frequently be neglected due to its negligible magnitude (and due to the fact that it is mathematically difficult to predict its value). It is most noticeable for objects that travel at high speeds (e.g., a skydiver or a downhill skier) or for objects with large surface areas. Air resistance
Tension Force **F_{tens}**	The tension force is the force that is transmitted through a string, rope, cable or wire when it is pulled tight by forces acting from opposite ends. The tension force is directed along the length of the wire and pulls equally on the objects on the opposite ends of the wire.
Spring Force **F_{spring}**	The spring force is the force exerted by a compressed or stretched spring upon any object that is attached to it. An object that compresses or stretches a spring is always acted upon by a force that restores the object to its rest or equilibrium position. For most springs (specifically, for those that are said to obey "Hooke's Law"), the magnitude of the force is directly proportional to the amount of stretch or compression of the spring.

Confusion of Mass and Weight

As mentioned above, the force of gravity acting upon an object is sometimes referred to as the **weight** of the object. Many students of physics confuse weight with mass. The **mass** of an object refers to the amount of matter that is contained by the object; the weight of an object is the force of gravity acting upon that object. Mass is related to how much *stuff* is there and weight is related to the pull of the Earth (or any other planet) upon that *stuff*. The mass of an object (measured in kg) will be the same no matter where in the universe that object is located. Mass is never altered by location, the pull of gravity, speed or even the existence of other forces. For example, a 2-kg object will have a mass of 2 kg whether it is located on Earth, the moon, or Jupiter; its mass will be 2 kg whether it is moving or not (at least for purposes of our study); and its mass will be 2 kg whether it is being pushed upon or not.

On the other hand, the weight of an object (measured in Newton) will vary according to where in the universe the object is. Weight depends upon which planet is exerting the force and the distance the object is from the planet. Weight, being equivalent to the force of gravity, is dependent upon the value of **g** - the gravitational field strength. On earth's surface **g** is 9.8 N/kg (often approximated as 10 N/kg). On the moon's surface, **g** is 1.7 N/kg. Go to another planet, and there will be another **g** value. Furthermore, the g value is inversely proportional to the distance from the center of the planet. So if we were to measure **g** at a distance of 400 km above the earth's surface, then we would find the **g** value to be less than 9.8 N/kg.