**Laws of Motion**

Newton changed our understanding of the Universe through the three laws of motion. These laws will be discussed in this lesson.

**First Law of Motion**- An object with no acceleration (whether it be by constant velocity or rest) will stay that way unless an outside force acts on it that is unbalanced (stronger).

**Second Law of Motion**- If an object’s motion is changed, it is proportional and in the direction of the (unbalanced) outside force that acted on it (in the direction of the net force)

**Third Law of Motion**- To every action, there is an equal and opposite reaction

A particular law that applies in space is the law of universal gravitation

**Law of Universal Gravitation**- Between any two objects in space, there is a force of attraction proportional to the product of the masses of the objects and inversely proportional to the distance of them squared.

The law of universal gravitation will be covered in more depth in the next lesson.

The First Law of Motion

Also known as the **law of inertia**, the first law of motion can be interpreted as ‘An object at rest, stays at rest. An object in motion, stays in motion.’

What does this mean?
There is a natural tendency for objects to continue doing whatever they’re doing. All objects resist changes in their state of motion. If there is no unbalanced force acting on the object, the object will resume its state.
Example: Let’s look at a ball is rolling down a hill. With nothing in its path, the ball will continue to roll down the hill. If a wall were to appear in the ball’s path, the ball’s motion would stop.
On the flipside if the ball was sitting still and nothing was acting on it, the ball wouldn’t move. If a force such as a push acts on the ball, the ball will move.

The Second Law of Motion

The second law can also be written as ‘Acceleration is produced when a force acts on a mass. The greater the mass of the object being moved, the greater the amount of force needed.

What does this mean?
The more mass an object has, the more force needed to accelerate the object.
Example: Think about pushing an object. Pushing an empty box is an easy task, but as the box is filled with more and more items, more force is needed to move the box.

This law gives an exact relationship between force, mass and acceleration. This relationship is:

$\vec{F}$ = m$\vec{a}$

 E.x.: A 200kg box is pushed with an acceleration of 5m/s2. Calculate the force needed to push the box.

This is a simple calculation; all we do is utilize the formula to determine the force.
$\vec{F}$ = m$\vec{a}$
$\vec{F}$ = (200kg)•(5m/s)
$\vec{F}$ = 1000N

Note- The unit used is called a **Newton**. The Newton is a standard metric unit abbreviated by N. The Newton is defined as the amount of force required to give a 1kg mass an acceleration of 1 m/s2.

The Third Law of Motion

The third law seems simple enough: ‘For every action, there is an equal and opposite reaction.’

What does it mean? For every force, there is a reaction force that is equal in magnitude, but opposite in direction. Whenever a force moves an object it gets pushed back in the opposite direction equally hard.

Example: When you’re standing, what keeps gravity from pushing you into the ground and beyond? Besides the force of gravity pushing down on you, there is a normal force pushing up with the same magnitude, but opposite direction (i.e. upwards).



Note- A **normal force** is defined as the force perpendicular to the surface with which an object is in contact. The force acts to prevent objects from ‘falling’ into the surface.

Practice Problems

Using the appropriate laws of motion, answer the following:

1. How does a seatbelt work?
A seatbelt works by utilizing the first law of motion. When a car breaks, the car stops but the person in the car is still moving forward at the same speed of the car. The seatbelt acts as the unbalanced force to stop the person from moving forward, similar to a ball hitting a wall.
2. Explain the motion of a rocket as it takes off into space
The motion of a rocket taking off into space utilizes the third law of motion. The action of the rocket is to push off the ground with a certain amount of force. The reaction force is the ground ‘pushes’ upwards against the rocket.
3. Given that an object is moving at 4m/s, how much force is needed to move the object if it is 300kg? What would the change in force be if the weight was increased to 500kg?
$\vec{F}$ = m$\vec{a}$
$\vec{F}$ = (300kg)•(4m/s)
$\vec{F}$ = 1200N

$\vec{F}$ = m$\vec{a}$
$\vec{F}$ = (500kg)•(4m/s)
$\vec{F}$ = 2000N

Change in force= 2000N-1200N= 800N

800N is the change in force.