Newton's Law of Motion and application

There are three laws are known as Newton's Laws of Motion.

First Law: A body will continue its state of rest or of uniform motion in a straight line unless it is compelled by an external force to change its state of rest or of uniform motion.

And,

a Force is an influence which can produce an acceleration or retardation in a body. Force is a vector quantity.

If $\vec{F} = 0$

then $\vec{v} = \text{const.}$

and $\vec{a} = 0$ (If $\vec{v}$ const then there is no acceleration)

If more than One force acts on a body then, the sum of all forces on the body is $\Sigma\vec{F} = 0$, then, $\vec{v} = \text{Const}$

and $\vec{a} = 0$.

Application of First law:

inertia (Example):

A bicycle or car will keep moving unless the rider or driver applies a frictional force through the brakes to stop it. A driver or passangers in moving car who is not wearing a seat belt will be thrown forward when the car suddenly stops because he remains in motion.

2nd Law:

The rate of change of momentum of a body is proportional to the impressed force and it takes place in the direction of the straight line in which the force acts.

mathematically, $\frac{d\vec{p}}{dt} \propto \vec{F}$ $\quad (\vec{p} = m\vec{v})$

Where, $\vec{p}$ is the momentum of the system and $\vec{F}$ is the applied force.

$\vec{F} = m\vec{a}$ From 2nd Law:

Let a body of mass m is moving with uniform velocity $\vec{v}$ and the applied force on the body be $\vec{F}$.

momentum of the body $\vec{p} = m\vec{v}$

So, the rate of change of momentum

$$\frac{d\vec{p}}{dt} = \frac{d}{dt}(m\vec{v})$$

According to the Newton's second Law of motion. $\frac{d\vec{p}}{dt} \propto \vec{F}$

or, $\vec{F} \propto \frac{d}{dt}(m\vec{v})$

or, $\vec{F} \propto m\frac{d\vec{v}}{dt}$ [$\because m$ is const]

or, $\vec{F} \propto m\vec{a}$ [$\because \vec{a} = \frac{d\vec{v}}{dt}$]

or, $\vec{F} = km\vec{a}$

Where, k is the proportionality const.

If $F = 1\ N$

$m = 1\ kg$

$a = 1\ ms^{-2}$

$\therefore k = 1$

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

For more than one force, the sum of Force will be

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

Which is the relation between force and acceleration.

and, $\vec{F} \propto \frac{d\vec{P}}{dt}$

Which is the relation between force and momentum.

First Law from 2nd Law:

From 2nd Law of motion, we know

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

When, applied force, $\vec{F} = \vec{0}$

$$m\vec{a} = \vec{0}$$

or, $\vec{a} = 0$ $(\because m \neq \vec{0})$.

or, acceleration $= 0$

So, there will not be any change in velocity.

i.e If $\vec{F} = 0$, $\vec{v} = \text{const.}$

$$\vec{a} = 0$$

which is the 1st law of motion.

Application:

Example:

* If you use the same force to push a truck and push a car, the car will have more acceleration than the truck, because the car has less mass.

* It is easier to push an empty shopping cart than a full one, because the full shopping cart has more mass than the empty one.

Third Law:

To every action there is an equal and opposite reaction.

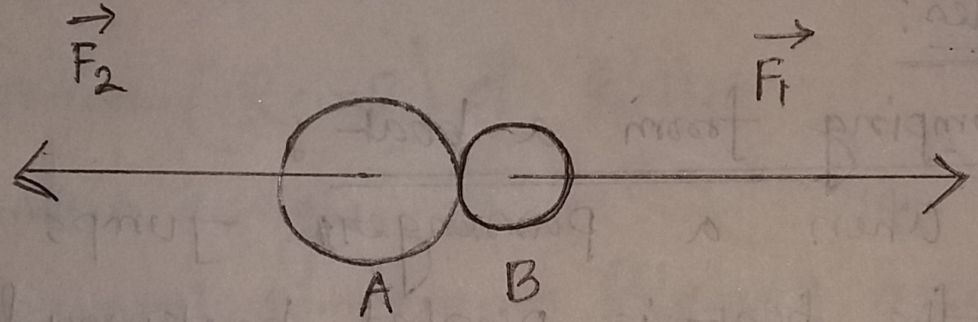

fig: 1

If a body A exerts force, $\vec{F_1}$ on another body B, then the body B will also exert equal and opposite force on A (fig1).

According to Law,

$$\vec{F_1} = -\vec{F_2} \quad \text{——— (1)}$$

Some important points connection with the third Law of motion.

(1) Action - reaction forces act on two different bodies A and B (or B and A).

(2) The force exerted on body ~~by~~ A by body B is equal in magnitude but opposite in sign of the force exerted on body B by body A.

Application:

Examples:

(1) Jumping from a boat:

When a passengers jumps from a boat, the boat is pushed backward due to the force exerted by the passenger on the boat. At the same time the boat exerts a reaction force on the passenger that enables him to reach the bank.

Here, the action is on the boat and the reaction is on the passenger.

(2) walking:

When we walk the back foot exert force ($\vec{F}$) obliquely on the ground (fig2).

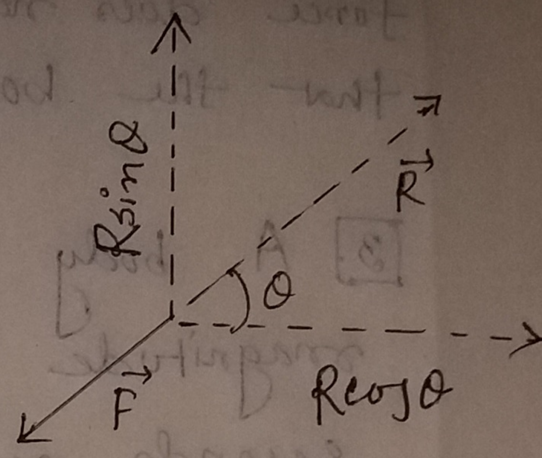

fig- 4.2

This is the action force. The ground exerts an equal and opposite force on foot. Let this reaction force be $\vec{R}$. The vertical component $(R\sin\theta)$ of $\vec{R}$ balances weight. the horizontal components $(R\cos\theta)$ accelerates us in the forward direction.

Problem :

$\boxed{1.}$ A force of 10 N produces a mass m_1 an acceleration of $5ms^{-2}$ and a mass m_2 an acceleration of $10\ ms^{-2}$. What acceleration would it produce if both the masses are tied together?

$\boxed{2}$ A force of 250 N acts of a rest body of mass 10 kg, if after 5 sec the force does not act, Find out the distance that the body travels in 10 sec.

3. A body was at rest. A force of magnitude 20 N acted on it for 4 seconds and then stopped. The body further travelled a distance of 54 m in 9 sec. Find the mass of body.

4. 15 N force acts on a body at rest of mass 2 kg. If after 5 sec, the force does not act on the body. Find the distance travelled in 8 sec from the begining.