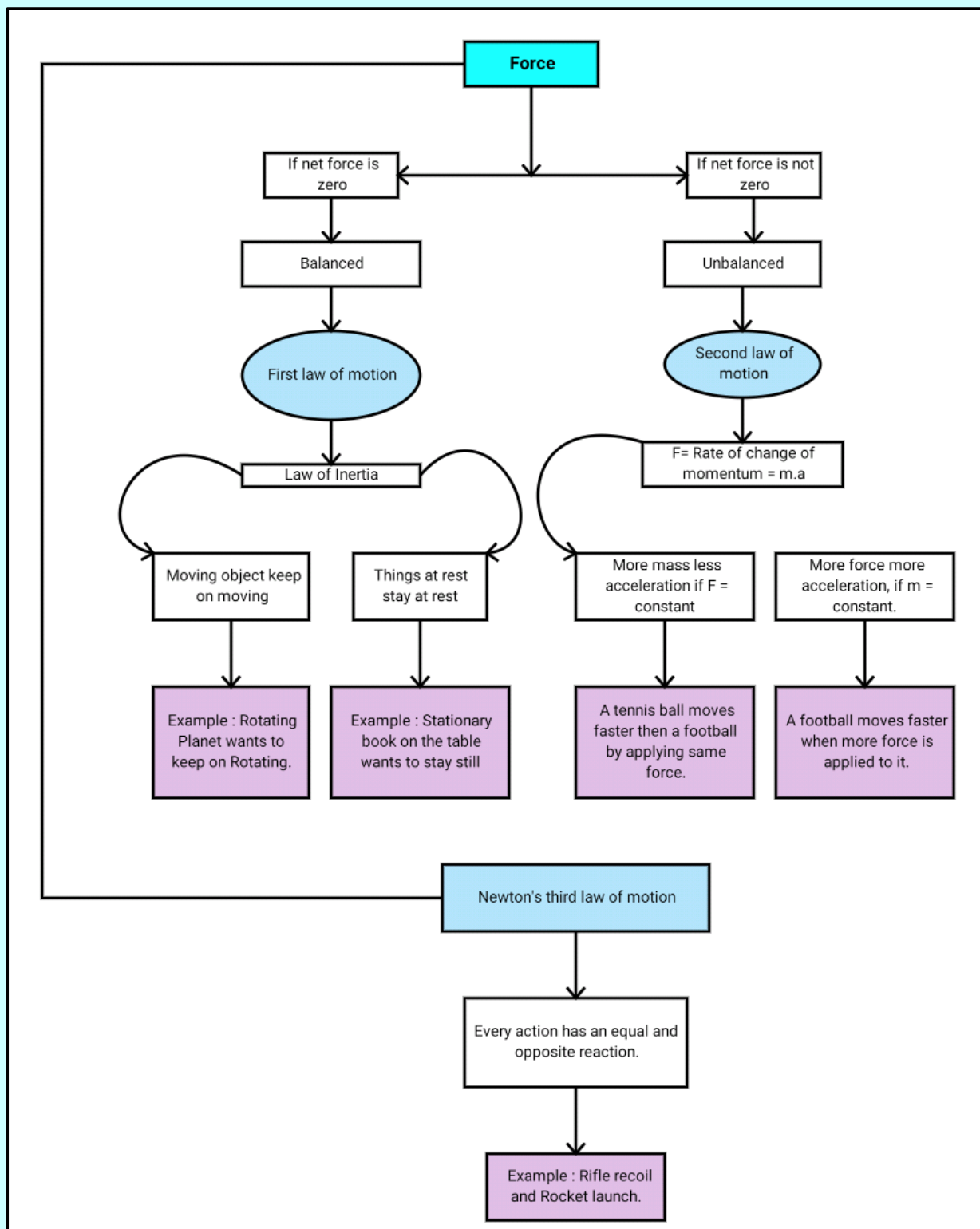


Force and Laws of Motion

Concept Map



GIST

➤ **Force:** Force is a push or pull which can produce or tends to produce the following effects:

1. Change in the direction of object.
2. Change in the speed.
3. Change in the shape.

TYPES OF FORCES

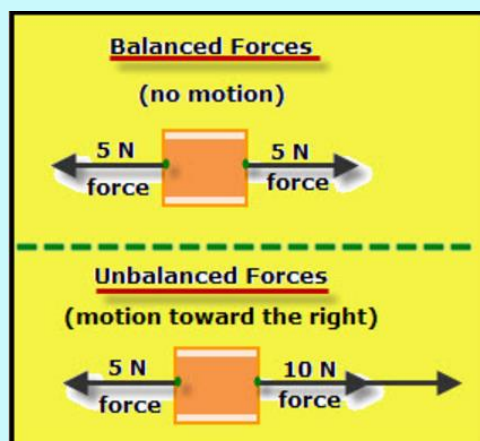
1. **Balanced forces** - If the resultant of all the forces acting on a body is zero, they are called balanced forces. They include the forces which are equal in magnitude but opposite in direction.

EFFECTS OF BALANCED FORCES

- Can change the shape and size of the body
- No effect on state of rest or state of uniform motion of the body

2. **Unbalanced forces** - If the resultant of all the forces acting on a body is not zero, the forces are called unbalanced forces.

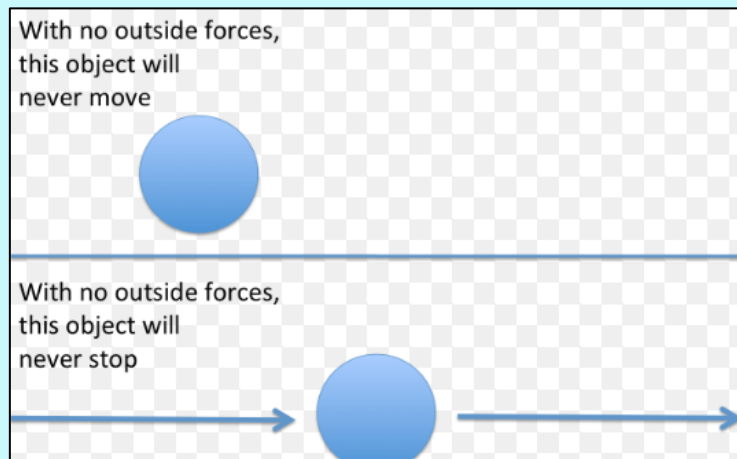
EXAMPLES OF BALANCED AND UNBALANCED FORCES



NOTE: - Unbalanced forces can change the state of rest or state of uniform motion or the shape of the body, but balanced forces can only change the shape of an object.

NEWTON'S 1st LAW OF MOTION:

An object remains in a state of rest or in uniform motion in a straight line unless compelled to change that state by an applied force. It is also called the law of inertia.



INERTIA

It is the natural tendency of objects to resist a change in their state of rest or of uniform motion.

Inertia of a body depends on its mass.

*Greater the inertia of a body greater will be the force required to bring a change in state of rest or of uniform motion.

TYPES OF INERTIA

INERTIA OF REST: A body at rest tends to remain at rest e.g. when a car or a bus starts suddenly, the passengers fall backward because the lower part of their body start moving with the car or the bus but the upper part of the body tries to remain at rest due to inertia of rest.

INERTIA OF MOTION: It is the tendency of the body to remain in motion e.g. when a running bus stops suddenly, the passengers are jerked forward because due to inertia the passengers tend to remain at the state of motion.

INERTIA OF DIRECTION: It is the tendency of a moving body to remain in the same direction e.g. when a car turns a corner sharply, we tend to fall sideways because of the inertia to continue moving in the same direction.

MOMENTUM

MOMENTUM (p) is the quantity of motion contained in a body. It is measured by the product of mass (m) & velocity (v) of an object.

$$p = mv \text{ (SI unit of 'p' is kg-m/s)}$$

- It is the vector quantity having direction same as that of the velocity.
- Momentum decides the impact of motion.

NEWTON 2ND LAW OF MOTION

“The rate of change of momentum is proportional to the applied unbalanced force in the direction of force”.

If a body of mass **m** is moving with velocity **u** and external force **F** changes its velocity to **v** in time '**t**', then:

$$\begin{aligned} \text{Force} &\propto \frac{mv - mu}{t} \\ \Rightarrow F &\propto \frac{m(v - u)}{t} \text{ (since force is denoted by 'F')} \\ \Rightarrow F &\propto m \frac{v - u}{t} \end{aligned}$$

Since, acceleration is the rate of change of velocity, i.e.

$$a = \frac{v - u}{t}$$

$$F \propto ma$$

F is proportional to change in momentum/time

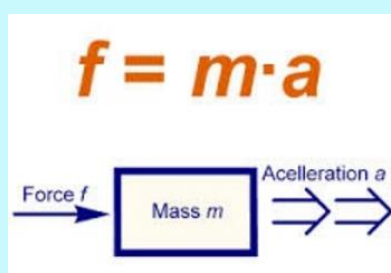
$$F = k * m * a \text{ (k is a constant)}$$

If, $k = 1$

$$F = ma$$

(The SI unit of force is newton (N) or kg-m/sec²).

In other words, the acceleration 'a' produced by a net force 'F' on an object of mass 'm', is directly proportional to the net force and is in the same direction as the net force.



APPLICATIONS OF NEWTON 2ND LAW OF MOTION

- A cricket player lowers his hand while catching the fast-moving ball so that the momentum of the ball changes to 0 in a longer duration of time. This reduces the force acting on the hands of the player due to the ball.
- A karate player breaks a slab of ice with a single blow because when he hits the tiles, a lot of momentum change occurs in a very short span exerting a greater force on the slab.

NEWTON'S 3rd LAW OF MOTION:

For every action there is an equal and opposite reaction.

- Forces always occur in pairs.
- Pairs of forces are opposite in direction.
- Pairs of forces act on different objects.
- If action is, A applies a force on B, then the reaction is B applies an equal and opposite force on A.

APPLICATIONS OF NEWTON 3rd LAW OF MOTION

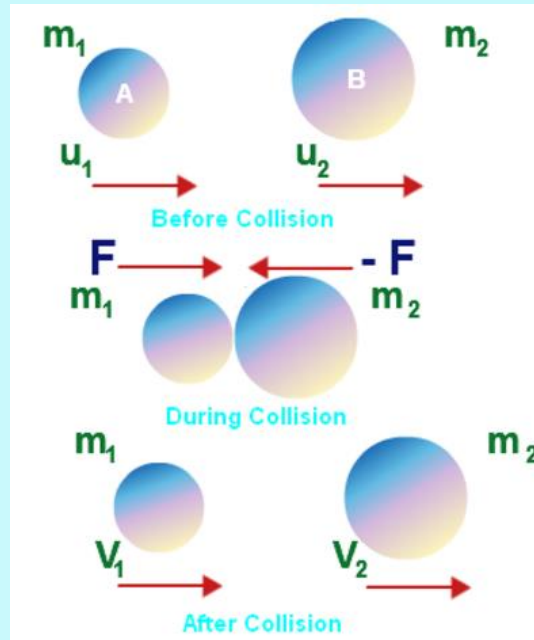
- In a jet aeroplane or a rocket, the hot gases come out of the nozzle with great force i.e. action and the aeroplane or rocket moves forward with a high speed, as a reaction.
- If we fill a balloon with air and hold it with the mouth downwards and when we release the balloon, the air rushes out vertically downwards in action and the balloon moves vertically upward, as a reaction.

LAW OF CONSERVATION OF MOMENTUM

“When two or more bodies act upon one another, their total momentum remains constant provided no net external force is acting”.

If two masses **m₁** and **m₂** which are moving with velocity **u₁** and **u₂** collide, such that their velocity changes to **v₁** and **v₂** respectively, then:

$$\mathbf{m_1u_1+m_2u_2=m_1v_1+m_2v_2; (when\ the\ net\ force\ is\ 0)}$$



This law is deduced from Newton's 3rd law of motion. All examples of Newton's 3rd law of motion can be explained in terms of law of conservation of momentum, e.g. velocity of gun and flying of jet planes etc.

