Newton's Laws of Motion

Inertia

- Definition

  Tendency of an object to maintain its state of rest or uniform motion in a straight line

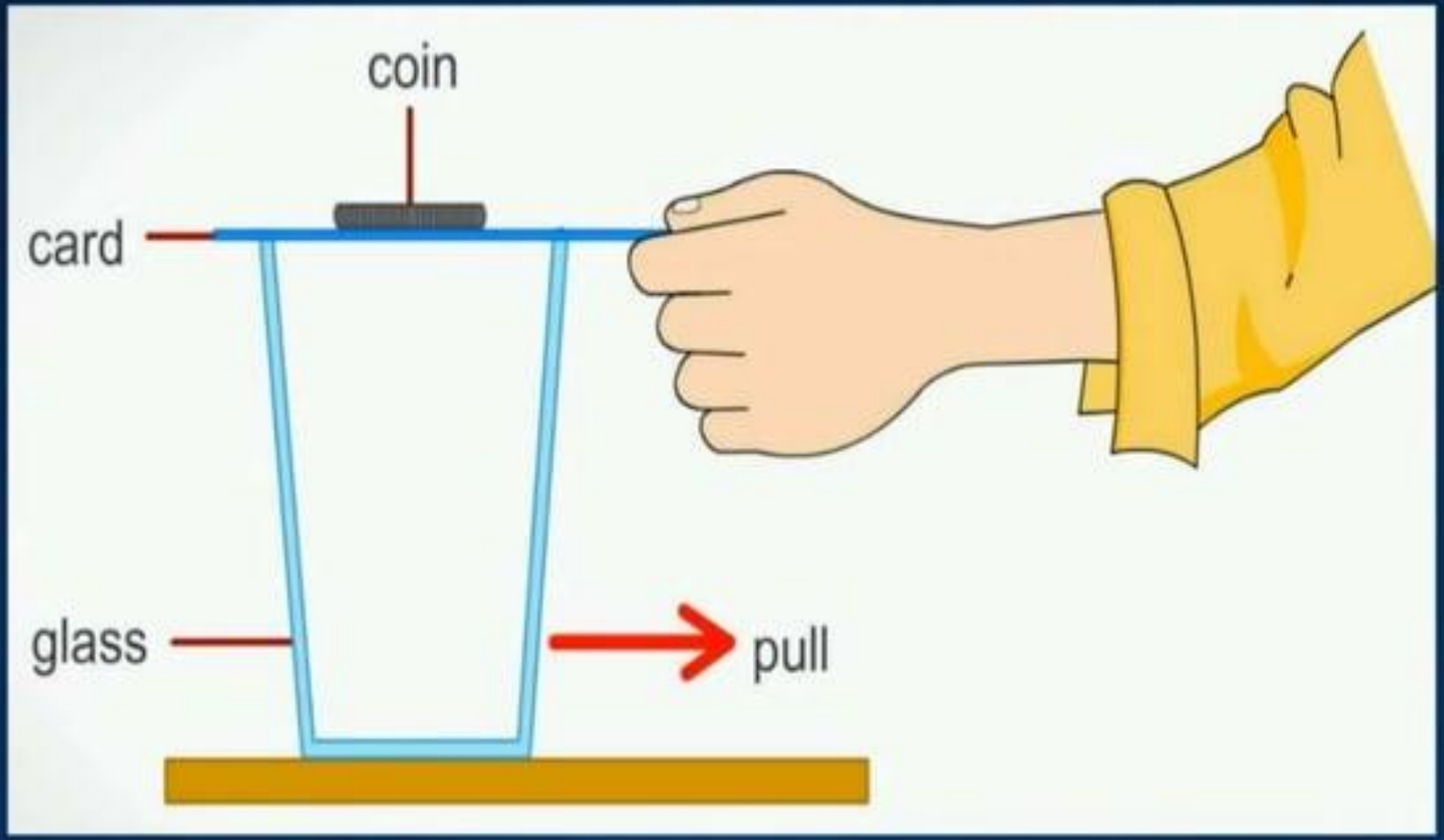
- Newton's first law

  "An object continues in its state of rest, or if moving it continues to move with uniform velocity, unless compelled by some external force to act otherwise"

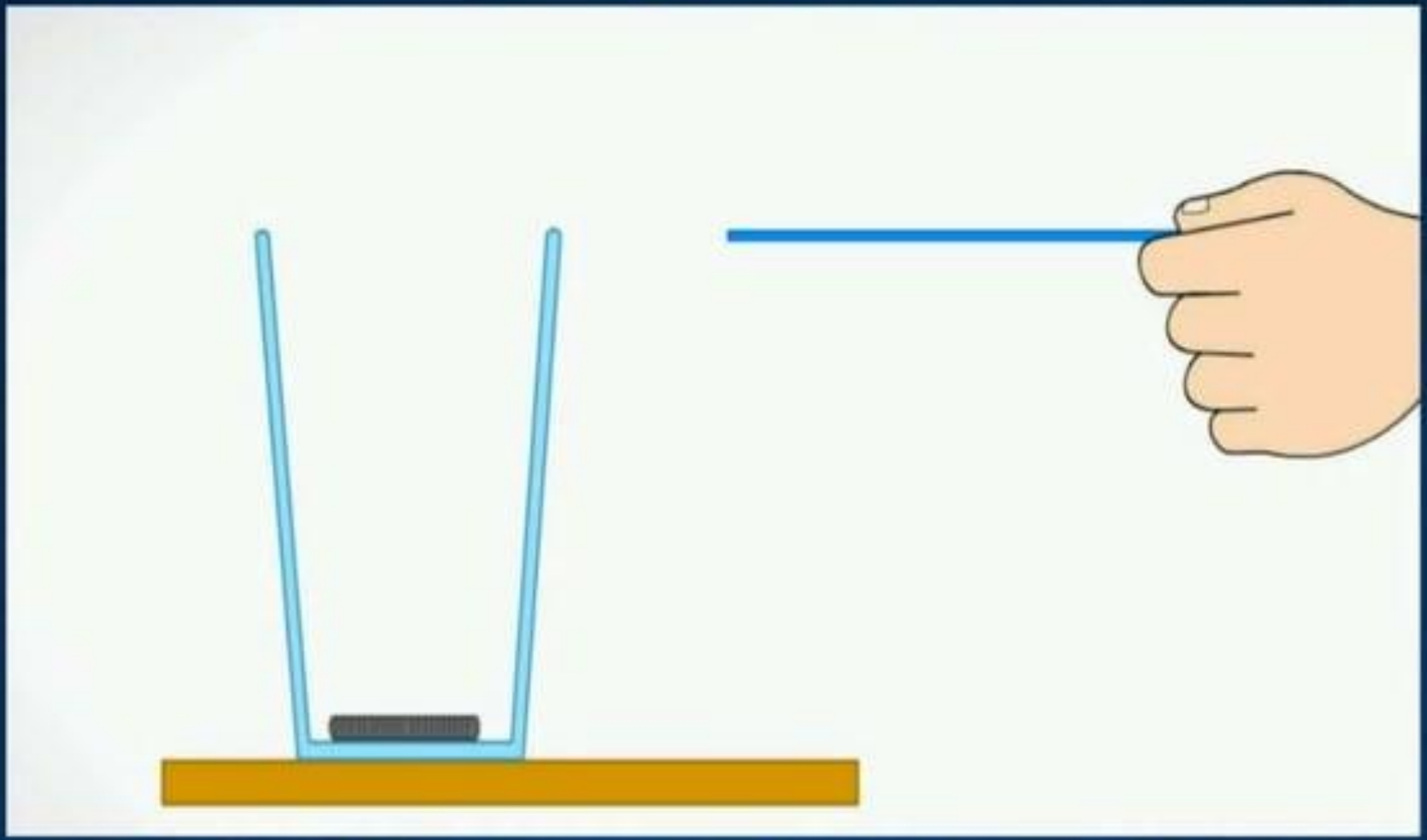
Types of Inertia

1. INERTIA OF MOTION
2. INERTIA OF REST
3. INERTIA OF DIRECTION

Observing Inertia



Observing Inertia



- Inertia of the coin resists change to its state of rest

Observing Inertia

Observing Inertia

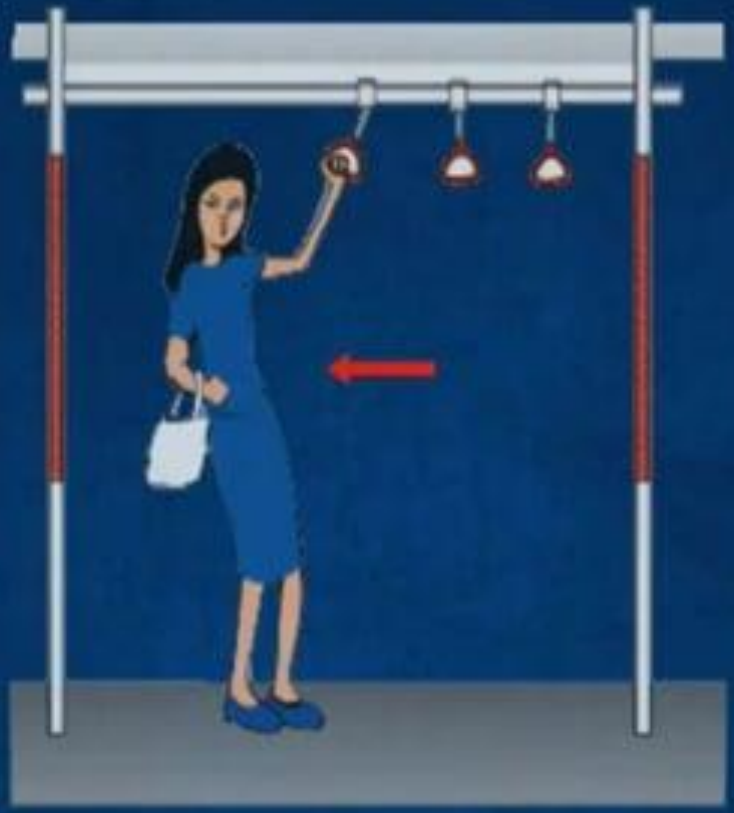
Observing Inertia

- Books on top of the one being pulled resist change to its state of rest

Situations Involving Inertia

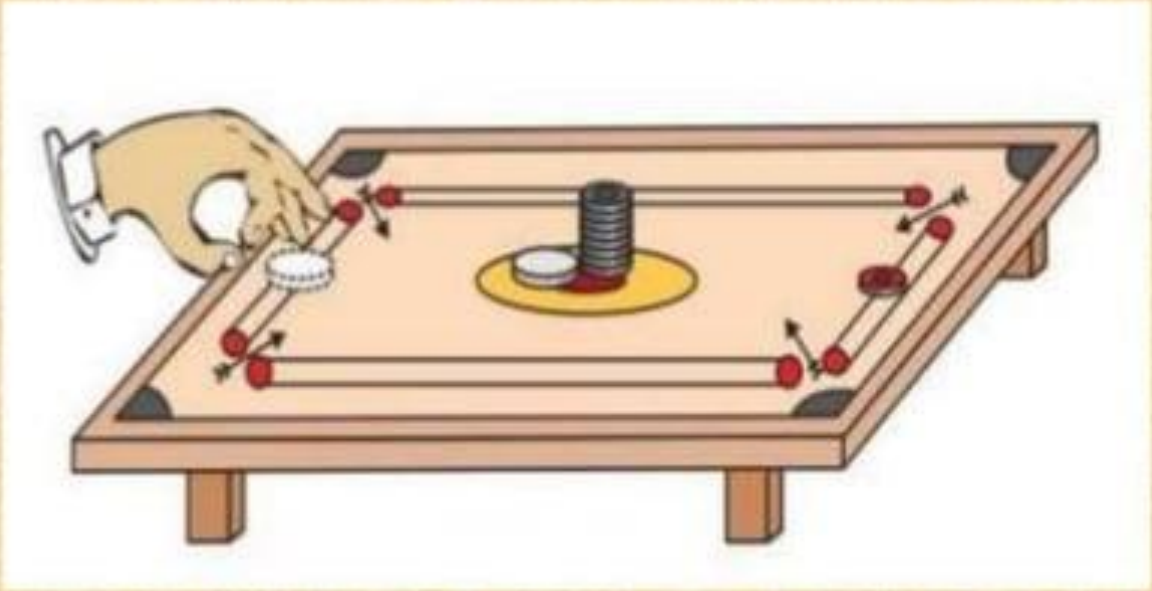
- Passenger has the inertia to remain at rest when the bus moves forward

Situations Involving Inertia



- When the bus suddenly stop, the inertia of the passenger has the tendency to keep moving forward

- Only the carom coin at the bottom of a pile is removed when a fast moving carom striker hits it.



Situations Involving Inertia

- Inertia of the passengers will maintain its original state that use to keep it moving at its original speed

Situations Involving Inertia

- Huge inertia of the plane causes it to continue moving over a long period of time until its inertia overcome by the overdecelerating action of friction

Inertia of Direction

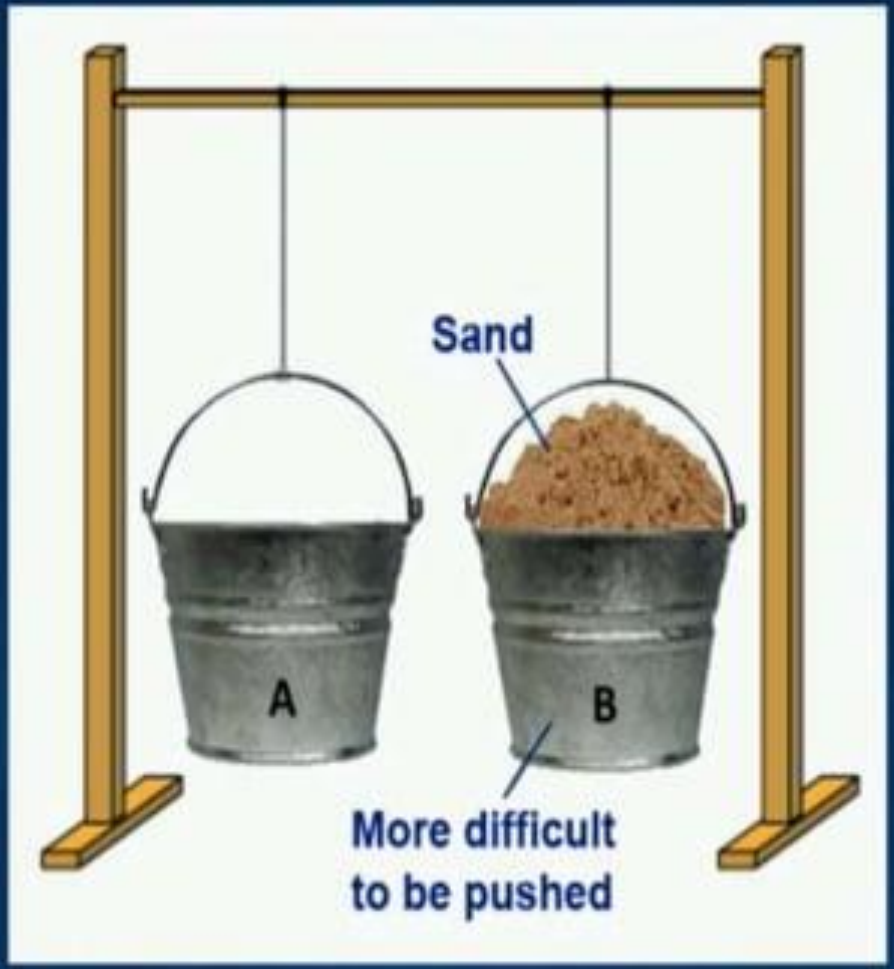
The inability of a body to change by itself its direction of motion.

E.g.: **When a car moves round a curve the person sitting inside is thrown outwards in order to maintain his direction of motion due to inertia of motion.**

Inertia and Mass

- The larger the mass of an object, the greater its inertia

Inertia and Mass



- The larger the mass of an object the larger its inertia

Inertia and Mass

- Example :

Inertia of motorcycle << Inertia of car

Momentum

- Definition : Momentum = Mass x velocity

  $p = m \times v$

- SI unit : $kg\ ms^{-1}$

- Vector quantity, has both magnitude and direction

Momentum

- Example :

Force, mass and acceleration

Newton's Second Law

- Definition :

$$\text{Force} \propto \frac{\text{final momentum - initial momentum}}{\text{time}}$$

The rate of change of linear momentum is directly proportional to its impressed force

Or

The Force is directly proportional to the product of mass and acceleration

Force, mass and acceleration

Newton's Second Law

$$F \propto \frac{mv - mu}{t}$$

$$F \propto ma$$

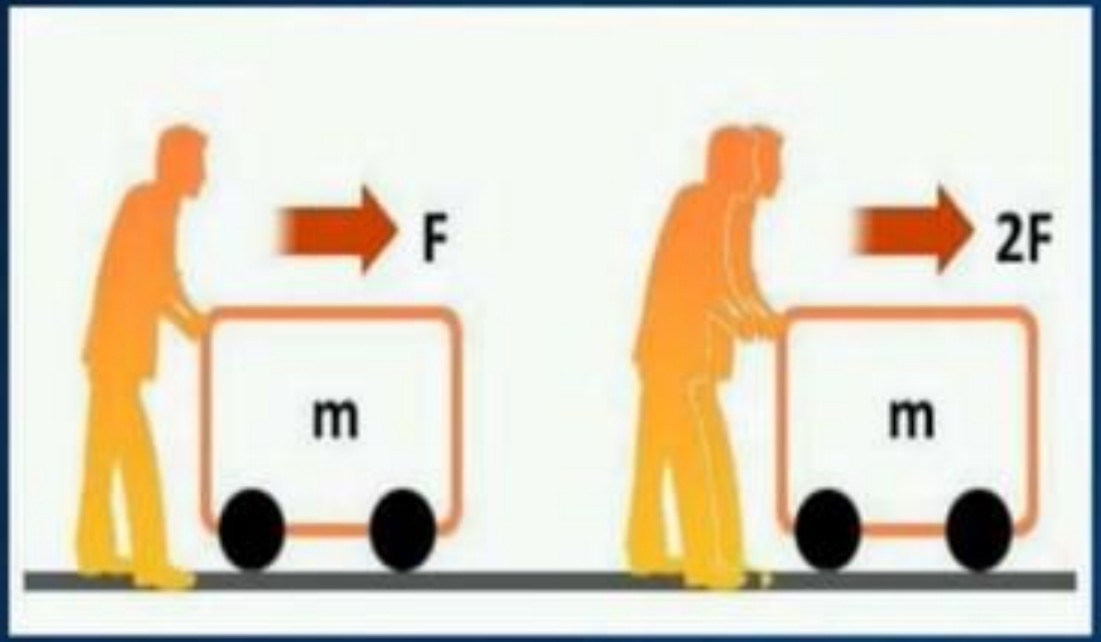
$$F = kma$$

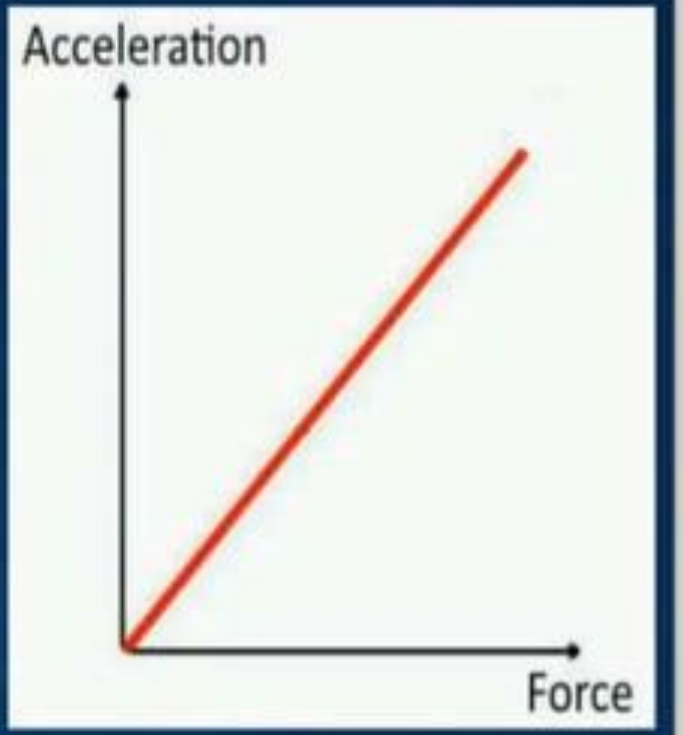
when $F = 1\ N$, $m = 1\ kg$ and $a = 1\ ms^{-2}$, thus, $k = \frac{F}{ma} = 1$

$$F = ma$$

Relationship between force, mass and acceleration

Relationship between acceleration and force

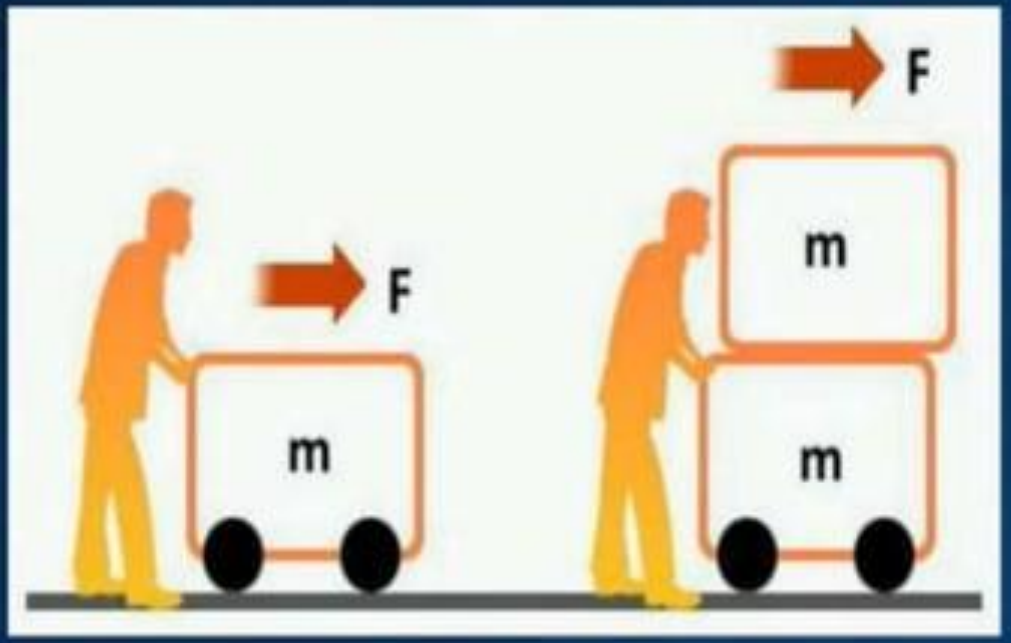


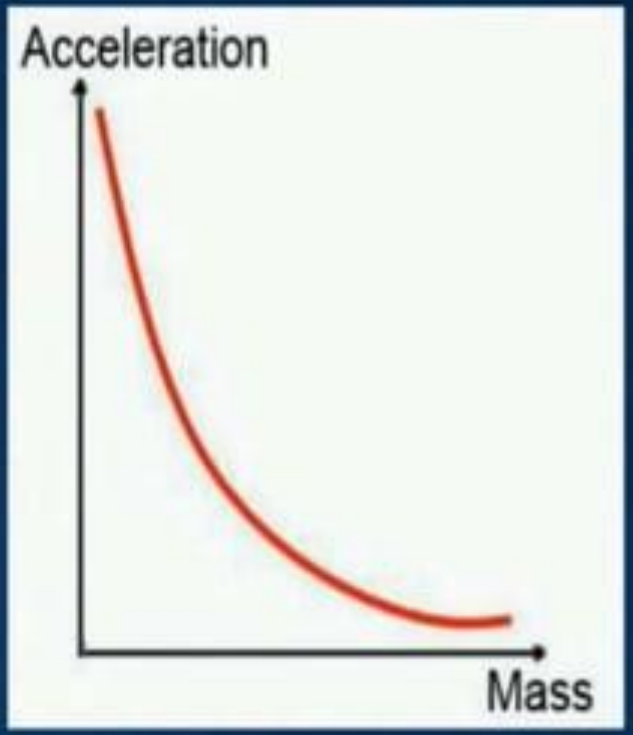


$a \propto F$

Relationship between force, mass and acceleration

Relationship between acceleration and mass





$$a \propto \frac{1}{m}$$

Impulsive force

Definition : Large force that acts over a short period of time during collision or explosion

$$F = \frac{mv - mu}{t} = \text{rate of change of momentum}$$

Impulse

Definition : Impulse = Ft

$Ft = mv - mu$

SI unit : $kg\ ms^{-1}$ or Ns

Impulsive force

- Increase of time impact will reduce the magnitude of force
- Decrease of impact time will increase the magnitude of the force

Decreasing the time of impact to increase the impulsive force

Football

- Large impulsive force to act on the ball

Decreasing the time of impact to increase the impulsive force

Hammer

- Impulsive force acts on the head of the nail

Increasing the time of impact to reduce the impulsive force

Long jump

- Sand pit lengthen the time of impact

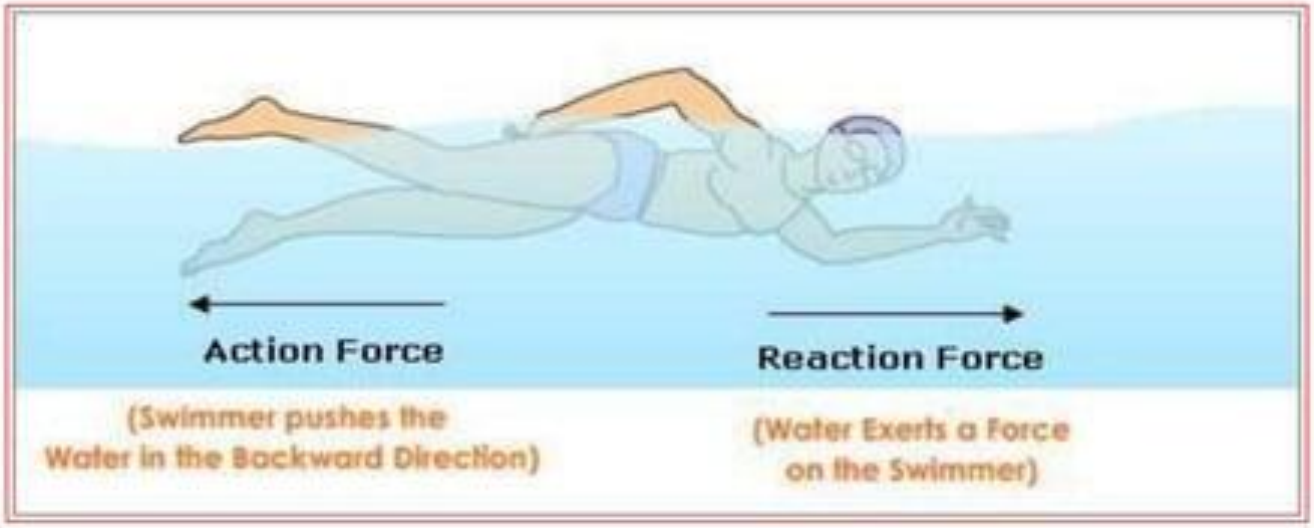
Increasing the time of impact to reduce the impulsive force

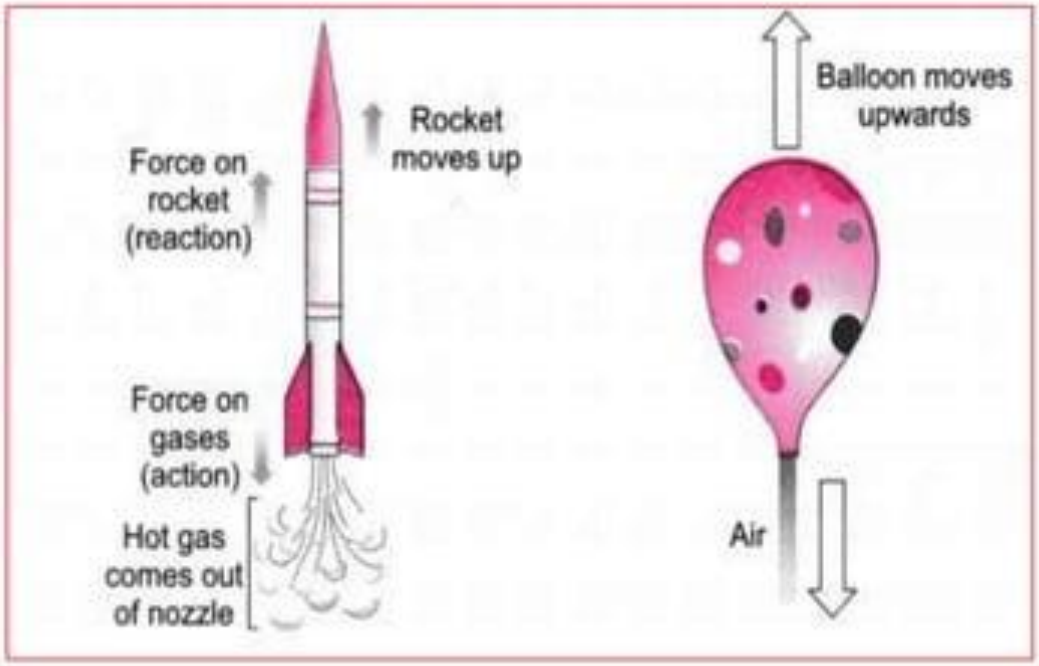
High jump

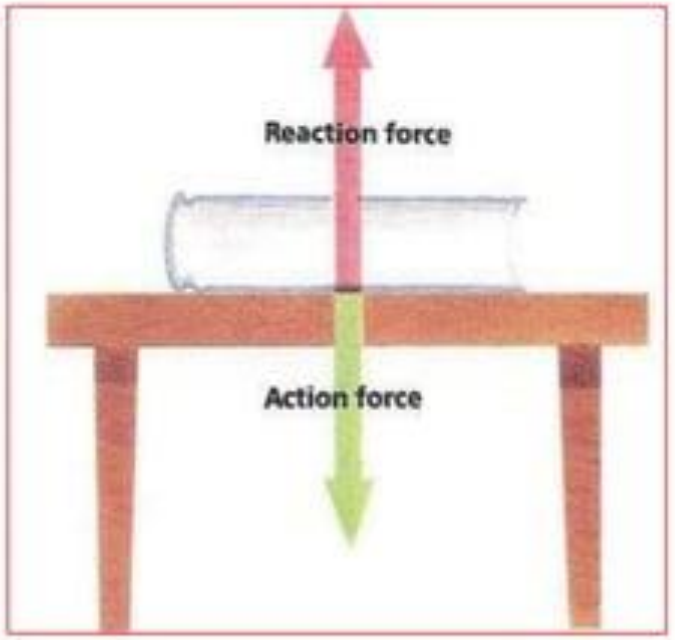
- Thick piece of soft mattress lengthen the time of impact

Newton's Third Law

- Newton's third law of motion states that "To every action, there will be an equal and opposite reaction.
- Action and reaction are equal in magnitude but opposite in direction


Action Force
(Swimmer pushes the Water in the Backward Direction)
Reaction Force
(Water Exerts a Force on the Swimmer)


Rocket moves up
Force on rocket (reaction)
Force on gases (action)
Hot gas comes out of nozzle
Balloon moves upwards
Air


Reaction force
Action force

A Bird in Flight