

FORCE & LAWS OF MOTION

A force is a push or a pull on some object .

S.I. Unit : Newton (N)

C.G.S. Unit : Dyne

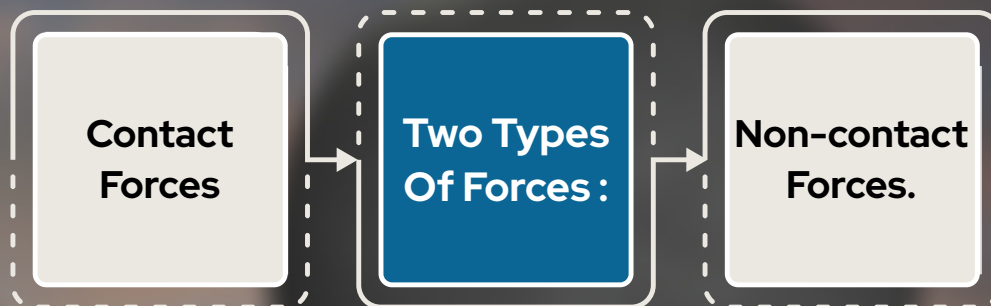
$1\text{ N} = 10^5\text{ Dyne}$



Man pushing a trolley



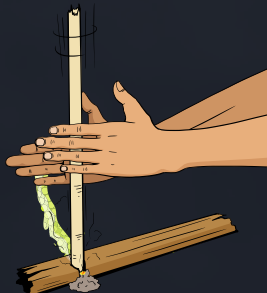
Boy kicking a football



Contact forces



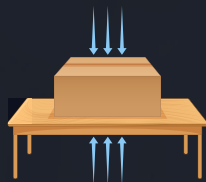
Muscular Force



Frictional Force

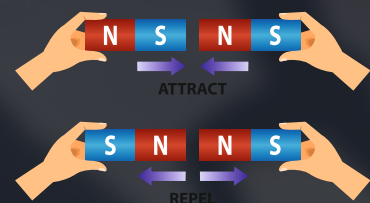


Tension



Normal Force

Non contact forces



Magnetic Force



Like Charge Repel



Opposite Charge Attract

Electrostatic Force

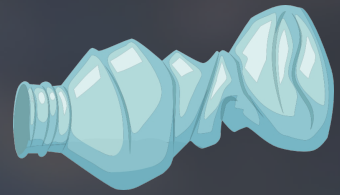


Gravitational Force

Effects of force

1

A force can distort an object i.e. it can change the shape and size of an object.



2

A force can start an object at rest i.e. it can move a stationary object.

3

A force can stop a moving object i.e. it can cause a moving object to come to rest.



Increasing



Decreasing



4

A force can change the speed or the magnitude of velocity of an object i.e. it can increase or decrease the speed of an object.

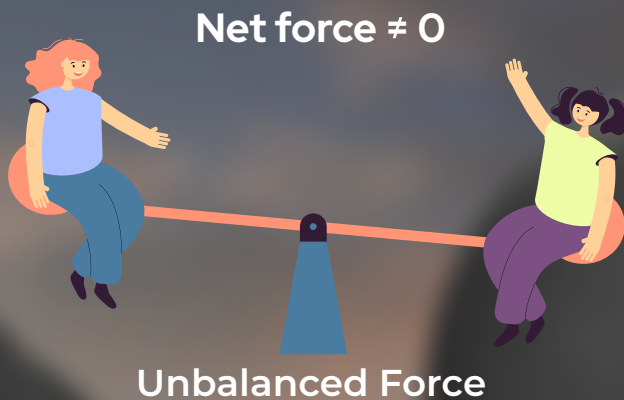
5

A force can change the direction of a moving object.



• **Balanced Forces**

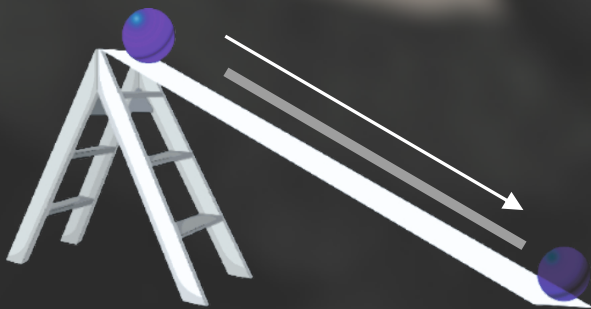
If a force or forces acting on an object does not change the state of rest or uniform motion, then they are called balanced forces.



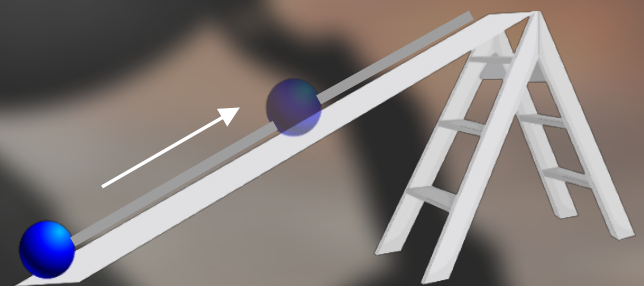
Unbalanced Forces •

If a force or forces acting on an object change the state of rest or uniform motion, then they are called unbalanced forces.

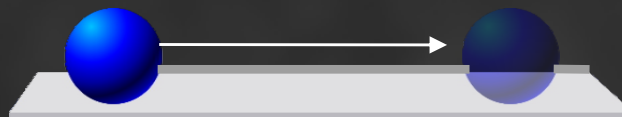
• **Galileo's inclined planes**



A ball rolling down the plane.
Velocity of ball increases
(accelerated motion).

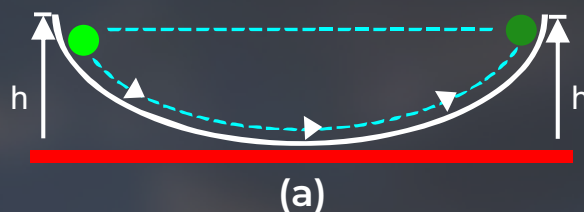


A ball rolling up the plane.
Velocity of ball decreases
(retarded motion).

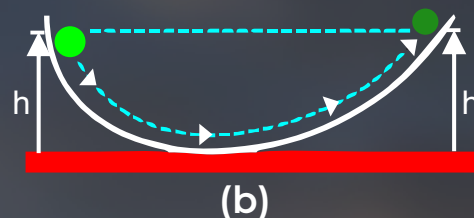


A ball rolling on a horizontal plane. Velocity of
ball remains constant (uniform motion).

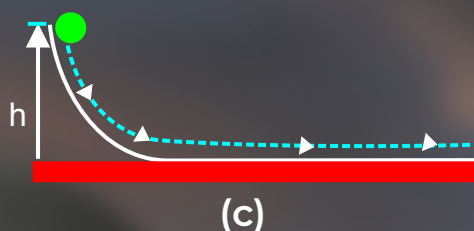
(a) In the ideal situation, when friction is absent, the final height of the ball is the same as its initial height .



(b) The ball must roll a greater distance as the angle of the second inclined plane on the right is reduced' .



(c) The ball must travel an infinite distance since it can never reach its initial height on first plane .



Inertia

(1) Inertia of rest

It is the tendency of an object to remain at rest until and unless any external force is applied.



(2) Inertia of motion

It is the tendency of an object to remain in the state of uniform motion. until and unless any external force is applied.



(3) Inertia of direction

It is the tendency of an object to maintain its direction. until and unless any external force is applied.



Inertia and Mass

Inertia of a body depends on its mass. The larger the mass, the larger is the inertia of the body.

• Air bags in car- a safety device

If a head-on collision of a car is violent enough, sodium azide undergoes a rapid chemical reaction to produce non-toxic nitrogen gas, which inflates an airbag.



• LINEAR MOMENTUM (OR MOMENTUM)

The linear momentum of a particle or an object that has a mass 'm' moving with a velocity 'v' is defined to be the product of the mass and velocity.

$$p = m \times v$$

The linear momentum of a particle is

- (i) Directly proportional to its mass
- (ii) Directly proportional to its velocity

• UNITS OF LINEAR MOMENTUM

S.I. Unit : kg m/s or kg m s⁻¹

(Another S.I. unit of momentum is Newton-second or N-s)

C.G.S. Unit : g cm/s or g cm s⁻¹

NEWTON'S LAW OF MOTION

• Newton's first law of motion

'Every object continues in its state of rest, or of uniform motion in a straight line, unless it is compelled to change that state by forces impressed upon it'.

Ex. – If pulled quickly, a tablecloth can be removed from underneath of dishes.



Tightening of seat belts In a car when it stops quickly.

• Newton's second law of motion

'The rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction in which the force acts'.

Ex. – Pushing a Car and a Truck, Hitting a Ball.

$$F = ma$$



Pushing a Shopping Cart



Two People Walking Together

• Newton's third law of motion

'whenever one body exerts a force on a second body, the second body exerts an oppositely directed force of equal magnitude on the first body'.

Ex. – During swimming
During walking



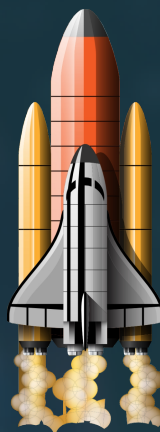
Firing of a bullet



A book lying on a table

• Rocket Propulsion

In a rocket engine, the highly combustible fuel burns at a tremendous rate.



• Conservation of momentum

Law of conservation of momentum states that for two or more bodies in an isolated system acting upon each other, their total momentum remains constant unless an external force is applied. Therefore, **momentum can neither be created nor destroyed.**



Before Collision = $m_1 u_1 + m_2 u_2$



Collision



After Collision = $m_1 v_1 + m_2 v_2$

Total momentum will remain conserve = $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$