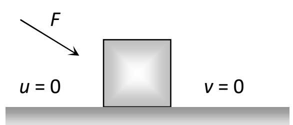
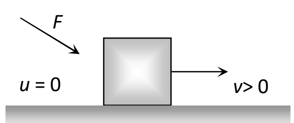
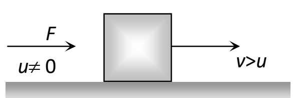
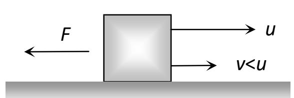
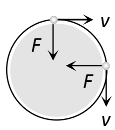
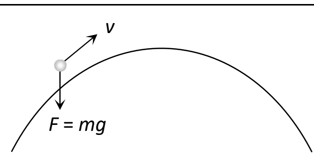
Force.

(1) Force is an external effect in the form of a push or pulls which

(i) Produces or tries to produce motion in a body at rest.

(ii) Stops or tries to stop a moving body.

(iii) Changes or tries to change the direction of motion of the body.

	Body remains at rest. Here force is trying to change the state of rest.
	Body starts moving. Here force changes the state of rest.
	In a small interval of time, force increases the magnitude of speed and direction of motion remains same.
	In a small interval of time, force decreases the magnitude of speed and direction of motion remains same.
	In uniform circular motion only direction of velocity changes, speed remains constant. Force is always perpendicular to velocity.
	In non-uniform circular motion, elliptical, parabolic or hyperbolic motion force acts at an angle to the direction of motion. In all these motions. Both magnitude and direction of velocity changes.

(2) Dimension: Force = mass × acceleration

$$[F] = [M][LT^{-2}] = [MLT^{-2}]$$

(3) Units: Absolute units: (i) Newton (S.I.) (ii) Dyne (C.G.S)

Gravitational units: (i) Kilogram-force (M.K.S.) (ii) Gram-force (C.G.S)

Newton: One Newton is that force which produces an acceleration of $1 m/s^2$ in a body of mass 1 Kilogram. $\therefore 1$ Newton $= 1 kg\, m/s^2$

Dyne: One dyne is that force which produces an acceleration of $1 cm/s^2$ in a body of mass 1 gram. $\therefore$ 1 Dyne $= 1 gm\, cm/\sec^2$

Relation between absolute units of force 1 Newton $= 10^5$ Dyne

Kilogram-force: It is that force which produces an acceleration of $9.8 m/s^2$ in a body of mass 1 kg. $\therefore$ 1 kg-f = 9.81 Newton

Gram-force: It is that force which produces an acceleration of $980 cm/s^2$ in a body of mass 1gm. $\therefore$ 1 gm-f = 980 Dyne

Relation between gravitational units of force: 1 kg-f = 10^7 gm-f

(4) $\vec{F} = m\vec{a}$ Formula is valid only if force is changing the state of rest or motion and the mass of the body is constant and finite.

(5) If m is not constant $\vec{F} = \frac{d}{dt}(m\vec{v}) = m\frac{d\vec{v}}{dt} + \vec{v}\frac{dm}{dt}$

(6) If force and acceleration have three component along x, y and z axis, then

$\vec{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}$ and $\vec{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$

From above it is clear that $F_x = ma_x$, $F_y = ma_y$, $F_z = ma_z$

(7) No force is required to move a body uniformly along a straight line.

$\vec{F} = ma$ $\therefore \vec{F} = 0$ (As $a = 0$)

(8) When force is written without direction then positive force means repulsive while negative force means attractive.

Example: Positive force – Force between two similar charges

Negative force – Force between two opposite charges

(9) Out of so many natural forces, for distance 10^{-15} metre, nuclear force is strongest while gravitational force weakest. $F_{\text{nuclear}} > F_{\text{electromag netic}} > F_{\text{gravitational}}$

(10) Ratio of electric force and gravitational force between two electrons $F_e / F_g = 10^{43}$

$\therefore F_e >> F_g$

(11) Constant force: If the direction and magnitude of a force is constant. It is said to be a constant force.

(12)Variable or dependent force:

(i) Time dependent force: In case of impulse or motion of a charged particle in an alternating electric field force is time dependent.

(ii) Position dependent force: Gravitational force between two bodies $\frac{Gm_1 m_2}{r^2}$

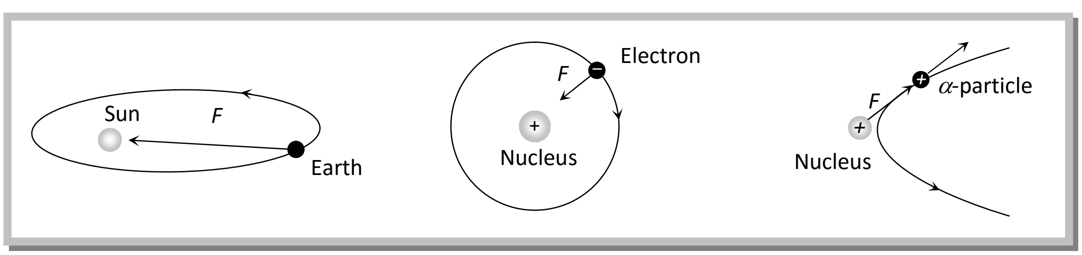
Or Force between two charged particles $= \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$.

(iii) Velocity dependent force: Viscous force $(6\pi\eta rv)$

Force on charged particle in a magnetic field $(qvB \sin\theta)$

(13) Central force:If a position dependent force is always directed towards or away from a fixed point it is said to be central otherwise non-central.

Example: Motion of earth around the sun. Motion of electron in an atom. Scattering of α-particles from a nucleus.



(14) Conservative or non-conservativeforce:If under the action of a force the work done in a round trip is zero or the work is path independent, the force is said to be conservative otherwise non conservative.

Example: Conservative force: Gravitational force, electric force, elastic force.

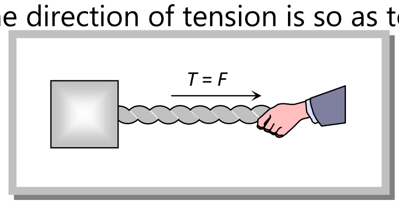
Non conservative force: Frictional force, viscous force.

(15) Common forces in mechanics:

(i) Weight: Weight of an object is the force with which earth attracts it. It is also called the force of gravity or the gravitational force.

(ii) Reaction or Normal force: When a body is placed on a rigid surface, the body experiences a force which is perpendicular to the surfaces in contact. Then force is called 'Normal force' or 'Reaction'.

(iii) Tension: The force exerted by the end of taut string, rope or chain against pulling (applied) force is called the tension. The direction of tension is so as to pull the body.



(iv) Springforce:Every spring resists any attempt to change its length. This resistive force increases with change in length. Spring force is given by $F = -Kx$; where x is the change in length and K is the spring constant (unit N/m).