Force

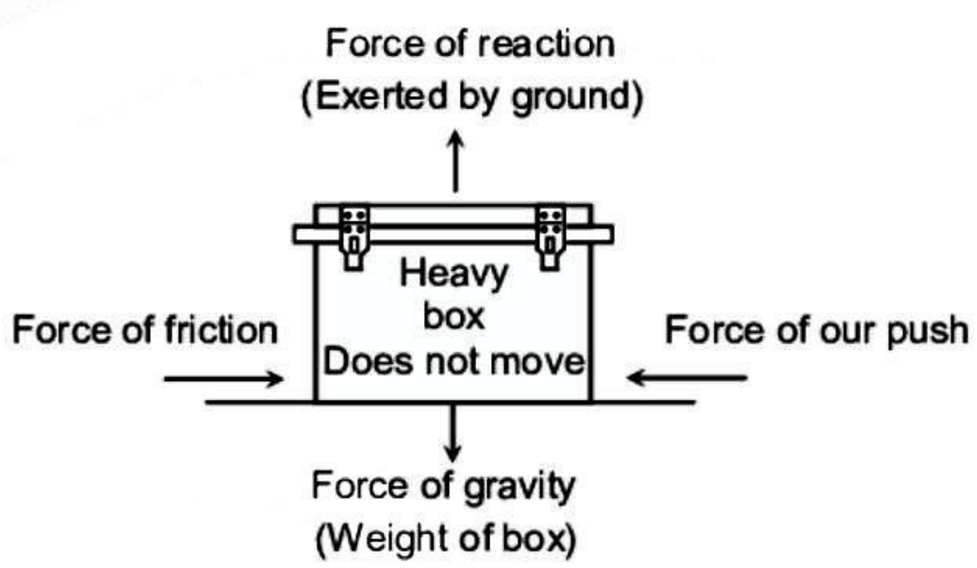
TYPES OF FORCES

The forces that we come across in our daily life, are divided into two types :

(i) Balanced Forces

(ii) Unbalanced Forces

(i) Balanced Forces: If the resultant of all the forces acting on a body is zero, the forces are called balanced forces.



When balanced forces act on a body (here a heavy box), they do not produce any motion in it.

(ii) **Unbalanced Forces :** If the resultant of all the forces acting on a body is not zero, the forces are called unbalanced forces.

(a) The heavy box shown in figure can be moved with a very strong force. This is because in that case the force of push will become greater than the opposing force of friction. An unbalanced force will then act on the heavy box and make it move.

(b) A ball rolling on the ground stops after some time because an unbalanced force of friction acts on it.

DIFFERENT TYPES OF FORCES:

(i) Force arises from interaction of bodies either due to contact or from a distance. So it can be classified as **contact force** and **non-contact force**.

Contact Force is such type of force, which arises when a body is in physical contact with another.

Example: String tension, spring force, reaction force and friction force etc.

Non-Contact Force is such type of force, which does not involve physical contact between two bodies, but act through empty space. It is also known as field force.

The force of gravitational attraction between two objects is an example of this type of force. Magnet and electric charges can also interact in vacuum.

(ii) Force can also be classified as **conservative** or **non-conservative**. If under the action of a force work done in a round trip is zero or work is path independent, the force is said to be conservative otherwise not. Gravitational, electric and elastic forces are conservative while frictional and viscous forces are non-conservative. In presence of Non-conservative force there is loss of mechanical energy, which is usually converted into heat.

(iii) Force can also be classified as **internal** and **external**. Internal forces are those, which arise from the interactions with other particles that are parts of the system while external

forces are those which originate beyond the system under consideration. Same force can be external or internal depending on the system. If we consider a body as the system the force of gravity of earth is external while if we consider body and earth as the system the force becomes internal. Total internal force acting on a system is always zero as these are parts of action-reaction pairs and cancel.

When we study different types of problems based on force, we should analyse different characteristic of forces, which helps in drawing the free body diagram (it is a diagram in which a body is isolated from its surroundings and the forces acting on it are drawn in the diagram) and writing the equations of motion.

CHARACTERISTICS OF FORCE

(i) Magnitude

(ii) Direction

(iii) Point of application

(iv) Line of action

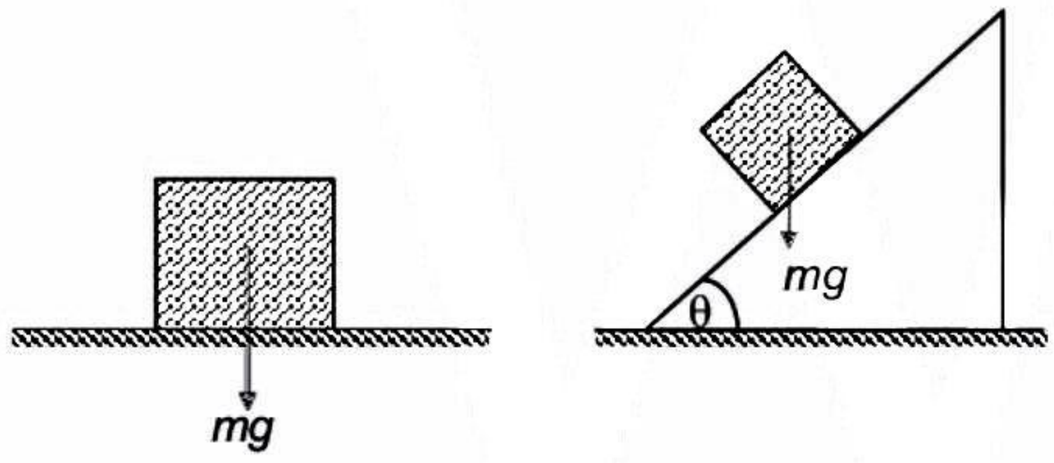
(a) Weight (*W*) : The weight of a body is the force by which it is pulled by the gravity of earth. If a body of mass '*m*' is located at a point where acceleration due to gravity is $\vec{g}$, the weight $\vec{W} = m\vec{g}$

(i) Magnitude = mg

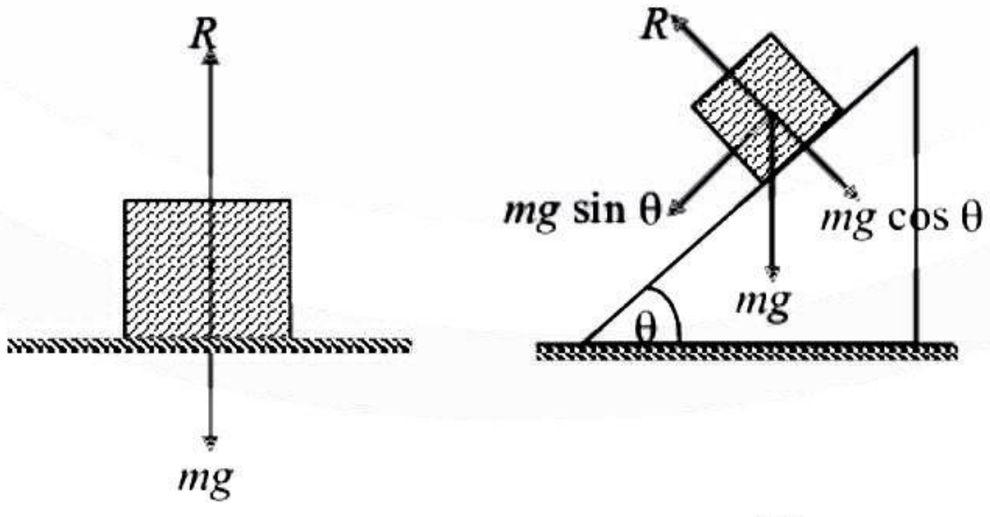
(ii) Direction will be towards the center of earth. To show the direction on the plane of paper we draw a line in the downward direction as shown below in the figure

(iii) Point of application is center of gravity of the block.

(iv) Line of action is vertically downward.



(b) Normal Reaction (*R*): When a body is pressed against a rigid surface, the body experiences a force, which is perpendicular to the surfaces in contact. This force is called 'normal force' or 'normal reaction'.



(a) (b)

(i) Magnitude of normal reaction is given by the action force perpendicular to the surface on which body is kept

in figure (a) $R = mg$

in figure (b) $R = mg \cos\theta$

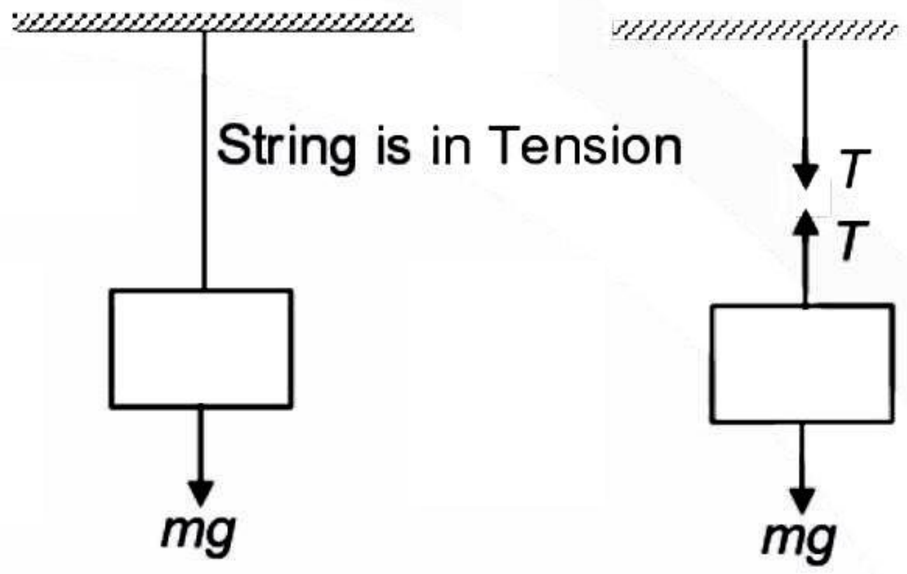
(ii) Direction of normal reaction in figure (a) is perpendicular to the surface in upward direction and in figure (b) is perpendicular to the incline surface.

(iii) Point of application is on the surface of contact.

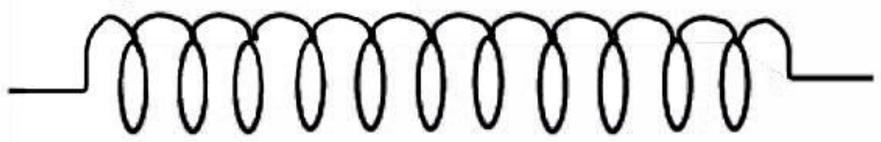
(iv) Line of action is perpendicular to the contact surface.

(c) String Tension (T): String tension is an elastic force. Whenever a body is connected with another body or ceiling through a string, and string is in tension. It acts in opposite direction to the applied force on the string; it means it pulls another body (in contact) to which it is connected.

String is assumed to be inextensible & massless. This is why the magnitude of string tension in whole string is taken same.



(d) Spring's Force: Springs can be of many types such as helical or spiral and are stretchable or compressible.



Regarding springs it is worth noting that:

(i) Springs are assumed to be massless. This is why the restoring *elastic force* in a spring is assumed to be the same everywhere.

(ii) For small stretch or compression, springs obey *Hook's law*, i.e. for a spring

Force $\propto$ stretch (or compression)

i.e., $F = -ky$ ... **(1)**

i.e., restoring force is linear. This force in a spring is not constant and depends on stretch (or compression) y. Greater the stretch (or compression) greater will be the force and

vice-versa. The negative sign indicates that the force applied by the spring is opposite to the displacement of the free end.