Ch – 9 Force & Law of Motion

Force:

It is the force that enables us to do any work.

Whenever we have to do anything either we pull the object or push the object. Therefore, force is defined as push or pull. In other words called force.

Example – to open a door, either we push iExample – to open a door, either we push it or pull it. A drawer is pulled to open and pushed to close.

Effect of Force:

Force can make a stationary body in motionying force you can move a ball.

Force can stop a moving body – For example by applying brakes you can stop a cycle or a vehicle which is in motion.

Force can change the direction of a moving object – By applying force, i.e. by moving handle you can change the direction of a running bicycle. Similarly by moving steering the direction of a running vehicle can be changed.

Force can change the speed of a moving body – By accelerating the speed of a running vehicle can be increased.

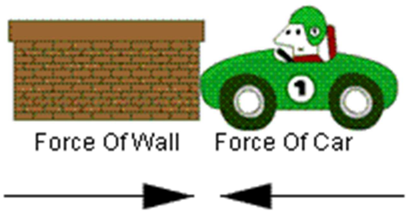
Force can change the shape and size of an object – By hammering a block of metal can be turned into a thin sheet. By hammering a stone can be broken into pieces.

Forces are of two types:

• Balanced Force

• Unbalanced Force

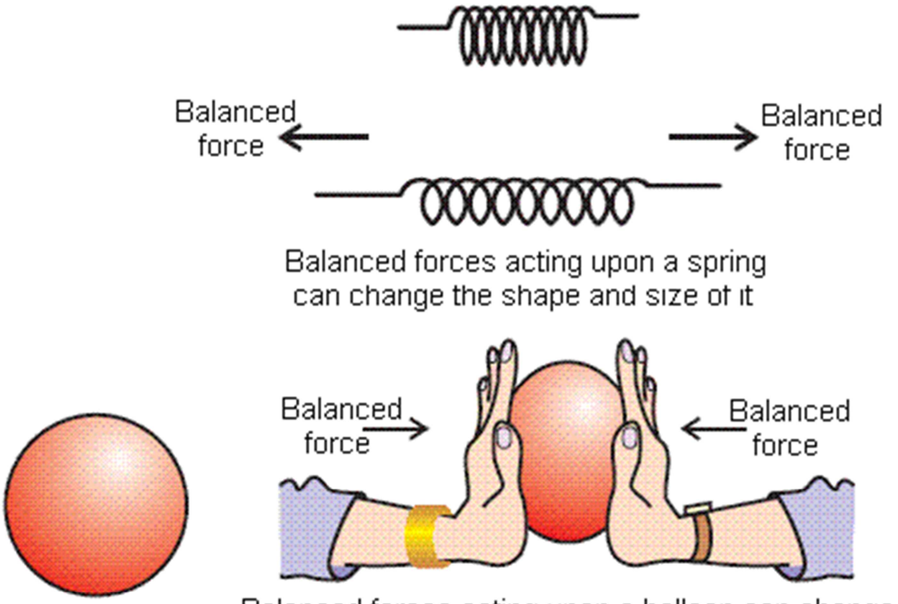
Balanced Forces – When the forces are applied on an object and resultant is zero, then the applied forces are called balanced forces.



Balanced Forces
(Ref:kerala.skoool.in)

Example - In the tug of war when both the teams apply similar force from both side, rope does not move either side, i.e. resultant is zero. Hence, it is a balanced force.

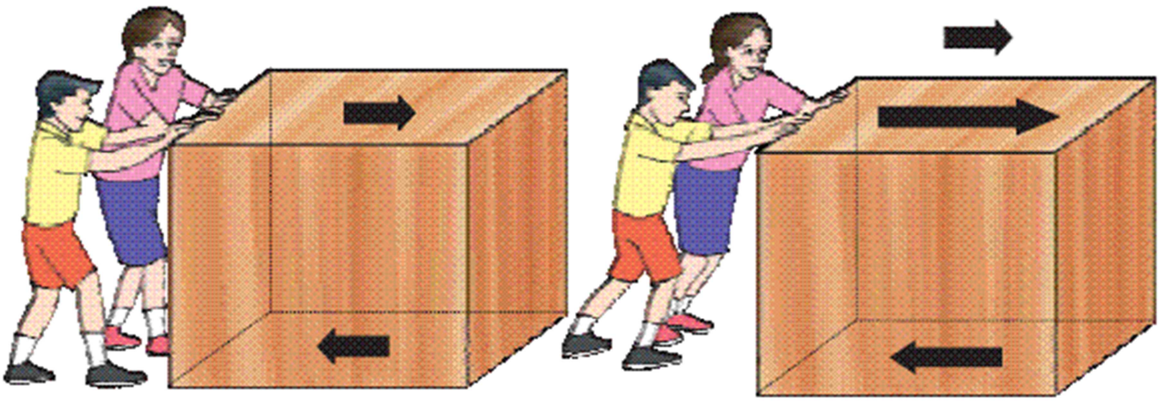
Balanced forces do not cause any change of state of an object. Balanced forces are equal in magnitude and opposite in direction.



Balanced forces acting upon a balloon can change the shpae and size of a balloon
(Ref: NCERT Book, class - ix - force)

Balanced forces can change the shape and size of an object. When you applies forces from both side on a balloon, the size and shape of balloon is changed.

Unbalanced Forces – When we apply force on an object and object moves, i.e. resultant is not equal to zero, the forces are called unbalanced forces. An object in rest can be moved because of applying balanced forces.



Balanced forces - cause no motion

Un-balanced forces move the box

(Ref: ncert book - class ix - force)

Unbalanced forces can do the following:

• Move a stationary object.

• Increase the speed of a moving object.

• Decrease the speed of a moving object.

• Stop a moving object.

• Change the shape and size of an object.

Laws of Motion:

Galileo Galilei: Galileo first of all said that object move with a constant speed when no forces act on them. This means if an object is moving on a frictionless path and no other force is acting upon that then object would be moving forever. That is there is no unbalanced force working on the object.

He propounded this theory after the observation of many moving objects.

But practically it is not possible for any object. Because to attain the condition of zero unbalanced force is impossible. Force of friction, force air and many other forces always acting upon an object.

Newton's Laws of Motion:

Newton studied the ideas of Galileo and gave the three laws of motion. These laws are popularly known as Newton's Laws of Motion.

Newton's First Law of Motion: Any object remains in the state of rest or of uniform motion in a straight line, until it is compelled to change the state by applying external force over it.

Explanation of Newton's First LNewton studied the ideas of Galileo and gave the three laws of motion. These laws are popularly known as Newton's Laws of Motion.

Newton's First Law of Motion: Any object remains in the state of rest or of uniform motion in a straight line, until it is compelled to change the state by applying external force over it.

According to Newton's First Law of Motion if a body is in rest then it will remain in rest unless unbalanced forces compel it to move. Second if a body is in motion then it will remain in motion unless unbalanced forces compel it to come in rest.

This means all objects resist to in changing their state. The state of any object can be changed by applying external forces only.

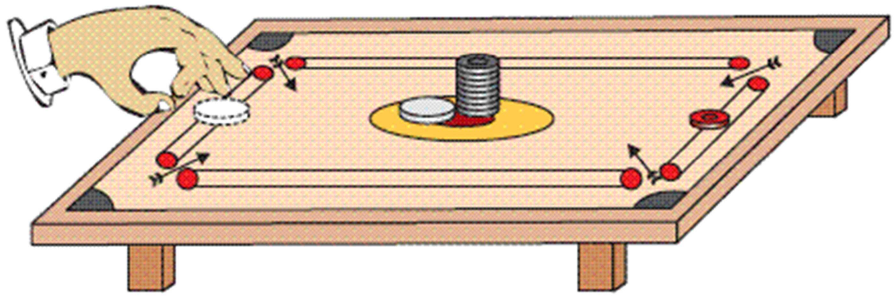
Newton's First Law of Motion in Everyday Life:

(a) If an object is kept on the ground at a certain place then that will remain on the ground unless a force is applied to move it.

(b) A person standing in a bus falls backward when bus is started moving suddenly. This happens because the person and bus both are in rest while bus is not moving, but as bus is started moving the legs of the person start moving along with bus but rest portion of his body has tendency to remain in rest. Because of this person falls backward if he is not alert.

(c) A person standing in a moving bus falls forward if driver applies brakes suddenly. This happens also because of the theory of Newton's First Law of Motion. When bus is moving, the person standing in it is also in motion along with bus. But when driver applies brakes the speed of bus decreases suddenly or bus comes in the state of rest suddenly, in this condition the legs of the person which are in the contact with bus come in rest suddenly while the rest part of his body has tendency to remain in motion with same speed. Because of this person falls forward if he is not alert.

(d) Before hanging the wet clothes over laundry line, usually many jerks are given to the cloths to get them dried quickly. Because of jerk droplets of water from the pores of the cloth falls on the ground. This happens because, when suddenly cloths are made in motion by giving jerks, the water droplets in it have tendency to remain in rest and they are separated from cloths and fall on the ground.



Carom coin kept at the bottom of pile moves only
(Ref:ncert book - class ix - force)

(e) When the pile of coin on the carom-board hit by a striker; coin only at the bottom moves away leaving rest of the pile of coin at same place. This happens also because of the theory of Newton's First Law of Motion. When the pile is struck with a striker, the coin at the bottom comes in motion suddenly because of the force applied by striker, while rest of the coin in the pile has tendency to remain in the rest and they vertically falls the carom board and remain at same place.

(f) Seat belts are used in car and other vehicles, to prevent the passengers being thrown in the condition of sudden braking or other emergency. Because in the condition of sudden braking of the vehicles or accident, the speed of vehicle would decrease or vehicle may stop suddenly, in that condition passengers may be thrown in the direction of the motion of vehicle because of the tendency to remain in the state of motion.

(g) The head of hammer is tightened on a wooden handle by banging the handle against a hard surface.

(h) Head rest is provided with the seat of car to prevent the whiplash injury of head in the case of accidents.

Mass and Inertia:

The property of an object because of which it resists to get disturbed its state is called Inertia. Inertia of an object is measured by its mass. A heavy object has more inertia than a lighter one. In other words inertia is the natural tendency of an object which resists the change in state of rest or motion of the object.

1) A constant force acts on an object of mass 5 kg for a duration of 2 s. It increases the object's velocity from 3 m s^{-1} to 7 m s^{-1}. Find the magnitude of the applied force. Now, if the force was applied for duration of 5 s, what would be the final velocity of the object?

Solution:

We have been given that u = 3 m s^{-1}

and v = 7 m s^{-1}, t = 2 s and m = 5 kg.

we have,

$$F = \frac{m \times (v - u)}{t}$$

$$F = \frac{5kg(7\ \mathrm{m}/s\ \ 3\ \mathrm{m}/s)}{2s}$$

Now, if this force is applied for a duration of 5 s (t = 5 s), then the final velocity can be calculated by

$$v = u + \frac{Ft}{m}$$

On substituting the values of u, F, m and t, we get the final velocity,

v = 13 m s^{-1}.

2) Which would require a greater force — accelerating a 2 kg mass at 5 m s^{-2} or a 4 kg mass at 2 m s^{-2}?

Solution:

we have F = ma.

Here we have m_1 = 2 kg; a_1 = 5 m s^{-2}

and m_2 = 4 kg; a_2 = 2 m s^{-2}.

Thus, $F_1 = m_1a_1$ = 2 kg × 5 m s^{-2} = 10 N;

and $F_2 = m_2a_2$ = 4 kg × 2 m s^{-2}= 8 N.

Or, $F_1 > F_2$.

Thus, accelerating a 2 kg mass at 5 m s^{-2} would require a greater force.

3) A motorcar is moving with a velocity of 108 km/h and it takes 4 s to stop after the brakes are applied. Calculate the force exerted by the brakes on the motorcar if its mass along with the passengers is 1000 kg.

Solution:

The initial velocity of the motorcar

u = 108 km/h

= 108 × 1000 m/(60 × 60 s)

= 30 m s^{-1}

and the final velocity of the motorcar

$v = 0$ m s^{-1}.

The total mass of the motorcar along with its passengers = 1000 kg

and the time taken to stop the motorcar, t = 4 s.

we have the magnitude of the force applied by the brakes F as

m(v – u)/t.

On substituting the values, we get

F = 1000 kg × (0 – 30) m $s^{-1/4}$ s

= – 7500 kg m s^{-2} or – 7500 N.

The negative sign tells us that the force exerted by the brakes is opposite to the direction of motion of the motorcar.

4) A force of 5 N gives a mass m_1, an acceleration of 10 m s^{-2} and a mass m_2, an acceleration of 20 m s^{-2}. What acceleration would it give if both the masses were tied together?

Solution:

we have $m_1 = F/a_1$; and

$m_2 = F/a_2$. Here, a1 = 10 m s^{-2};

$a_2 = 20$ m s^{-2} and F = 5 N.

Thus, m_1 = 5 N/10 m s^{-2} = 0.50 kg; and

m_2 = 5 N/20 m s^{-2} = 0.25 kg.

If the two masses were tied together, the total mass, m would be

m = 0.50 kg + 0.25 kg = 0.75 kg.

The acceleration, a produced in the combined mass by the 5 N force would be,

a = F/m = 5 N/0.75 kg = 6.67 m s^{-2}.

Newton's 2^{nd} Law of Motion: The acceleration a of a body is parallel and directly proportional to the net force 'F' acting on the body, is in the direction of the net force, and is inversely proportional to the mass m of the body, i.e., F = ma.

Third Law of Motion: there is always an equal and opposite reaction: or the forces of two bodies on each other are always equal and are directed in opposite directions.