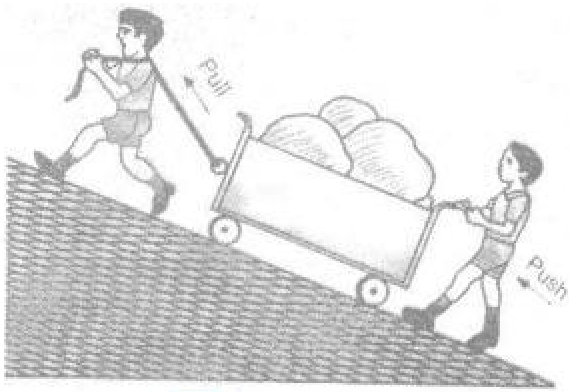
FORCE & LAW'S OF MOTION

INTRODUCRTION : From our day to day experience, we all are familiar with the concept of 'Force' While opening a door, lifting a bucket or a bag, kinetic a football or throwing a stone, we have to act differently and in many ways. We are either pushing or pulling the object. No non-living object moves on its own. We have to apply the effort in the form of push or pull. This pull or push is called force. Thus a force is an external agency that displaces or tends to displace a body from its position of rest. The direction in which the object is pushed or pulled is called the direction of the force. Force has both magnitude and direction. It is a vector quantity



FROCE : Force is the 'push' or 'pull' which can make a body move, stop a moving body, change the direction and speed of a moving body

UNITS OF FORCE

The unit commonly used for measuring force is called kilogram force (Symbol kgf.)

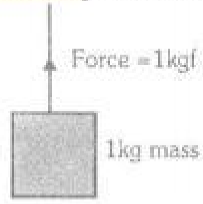
How big is the kilogram force ? It is the force required to vertically life a body a mass of 1 kg. In other words, the force of gravity acting on 1 kg mass is one kgf.

However. For measuring smaller force. The unit is gram force (symbol gf).

One gram force (lgf) is the force required to lift a mass of 1 g vertically

As, 1 kg mass is equal to 1000 g. therefore

1 kgf = 1000 gf



In SI system, the unit of force is called Newton (symbol N).

It has been found that one kilogram force is equal to 10 newtons. Actually 1 kgf = 9.8 However, to simplify, it is taken as 10 N. a

Thus , if was have to lift a mass of 1 kg vertically, the force required in the International system of units is10 N

10 N force is needed for lifting mass = 1 kg

or 10 N force is needed for lifting mass = 1000 g

1 N force is needed for lifting mass = 100 g

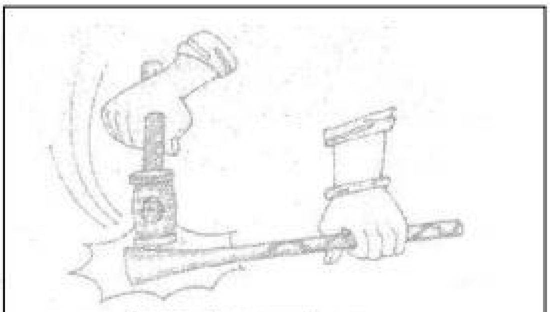
EFFET OF FORCE

1. EFFCT ON SHAPE

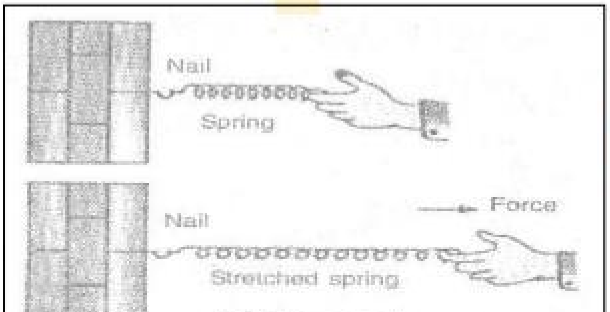
Ex. 1

The forces exerted by the fingers change the shape of the rubber ball.

Ex.2


Force changes shape

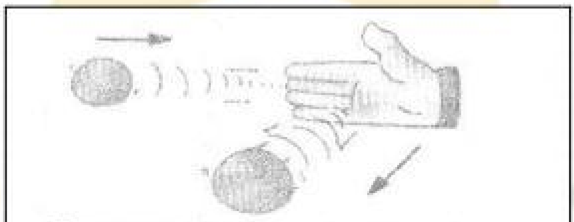
Ex.3



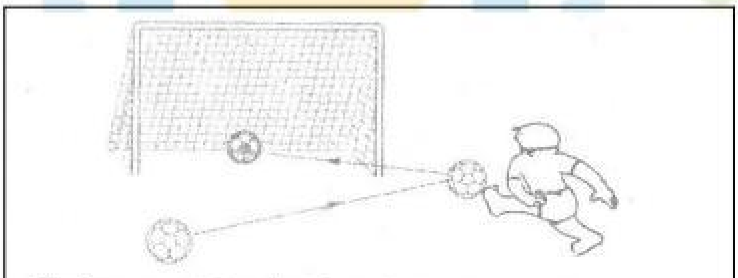
Spring expands

2. EFFECT ON MOTION & DIRECTION

Ex.1

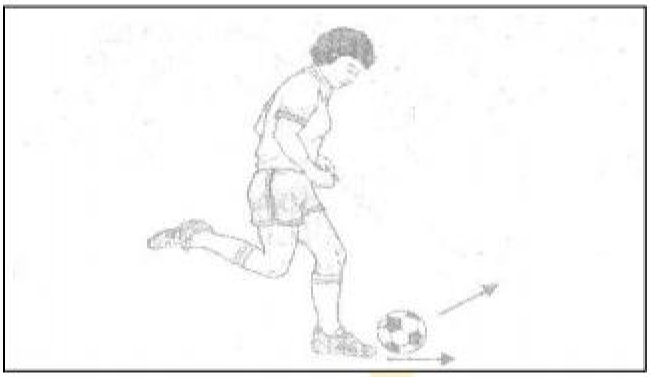

Force can change the direction of motion

Ex.2

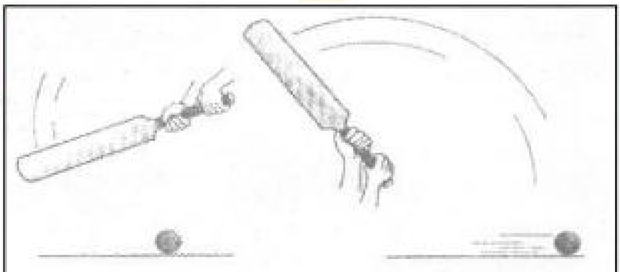

The force exerted by the player changes the direction of the ball.

Ex.3

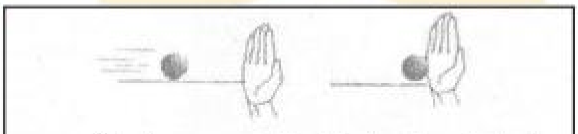
Ex.4



4. **EFFECT ON SPEED**



The force exerted by the bat increases the speed of the ball from zero to some value.



The force exerted by the hand on the ball decreases the speed to zero.

KINDS OF FORCES

5. ***CONTACT OF NON-CONTCT FORCE :***

CONTACT FORCE : The force which act on a body either directly or through some connector are called contact forces.

Example : Biological force, muscular force, mechanical forces and frictional forces are the example of contact forces.

NON-CONTACT FORCE : The forces which do not make a direct contact with a body and act through space, without any connector are called non-contact forces.

Example :

(i) The force of gravity of the earth is non-contact force which attracts all bodies the earth

(ii) The electrical force can pull tiny bits of dry paper is a non-contact force.

(iii) A magnet can attract common pins of steel from a distance and hence the magnetic force is non-contact force

MUSSULAR FORCE

This force produced by the muscles of living is called muscular force or biological force.

MECHANICAL FORCE

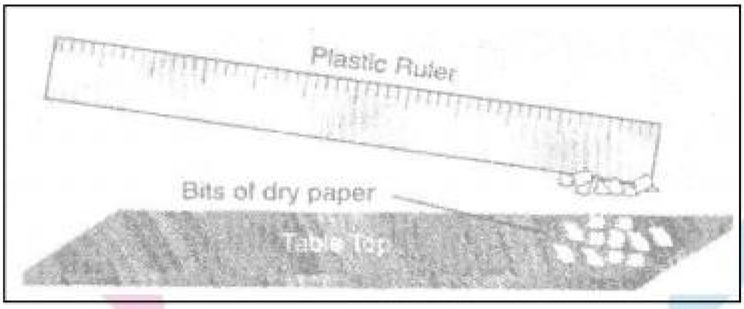
The forces generated by mechanes are called mechanical force

ELECRICAL FORCE

Electrical force is another kind of force which can push of pull tiny objects

ACTIVIY : To show electric force attracts tiny bits of paper.

Materials required : Small bit of dry paper. A plastic ruler.

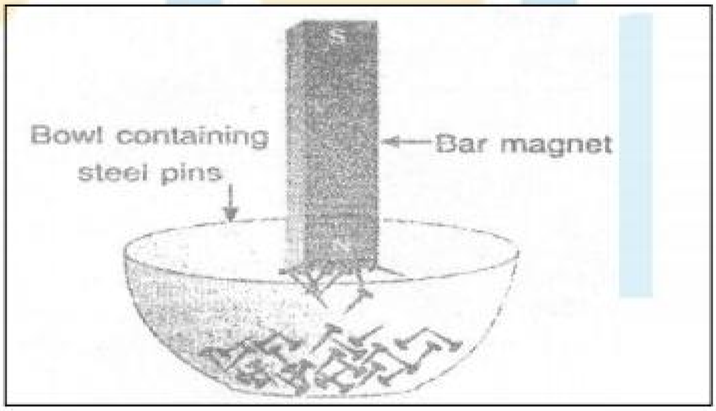


MAGNETIC FOREC : The strange property of some substance of attract iron or steel object towards itself is called magnetic property. The substance which has the above property is called a magnet.

As the subject of iron or steel move towards magnet, therefore we can say the they are acted upon by the force of magnet

ACTIVITY : To prove that a magnet attracts iron and steel.

Materials required : A bowl containing common pins. A magnet.



FRICTION FORCE :

A force acts at the surface of contact, when on body moves or tends to move upon another body is called the force of friction.

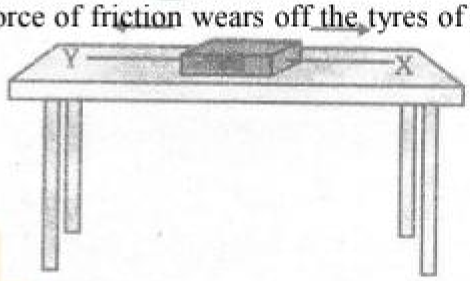
The force of frication has the following properties :

(i) It is produced only when on body is made to move upon another body.

(ii) It always opposes the motion of the body and tries to stop the body .

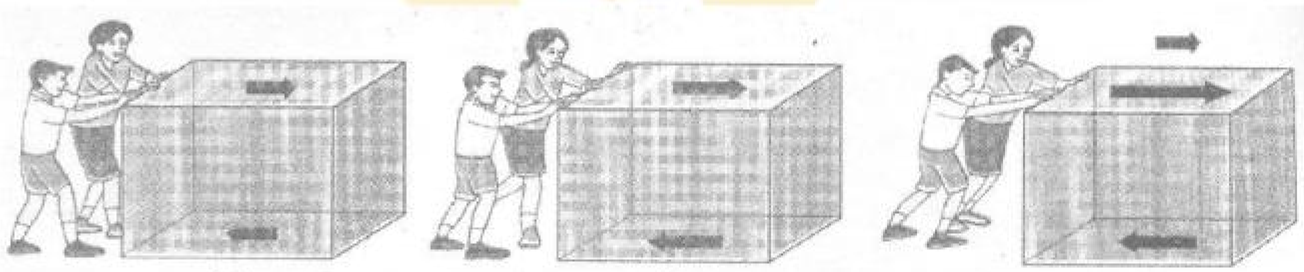
(iii) It wears off the surface of contact of two bodies.

It is the force of friction which makes it different for us to move heavy object such as large boxes; carts laden with different kinds of substance, etc. Again, it is the force of friction wears off the tyres of our bicycle, cars, trucks, etc.



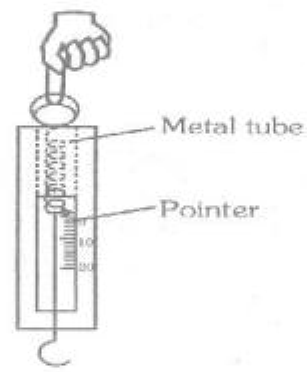
RESULTATN FROCE : It a single force acting on a body produces the same acceleration as produced by a number of force, that single force is called the results of these individual forces.

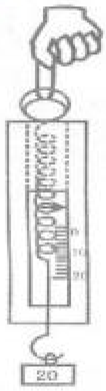
Balanced and unbalanced force : If a set of forces acting a body produces no acceleration in it, force are said to be balanced. It it produces a nonzero acceleration, the force are said to be unbalanced.



(a) (b) (c)

SPRING FORCE :

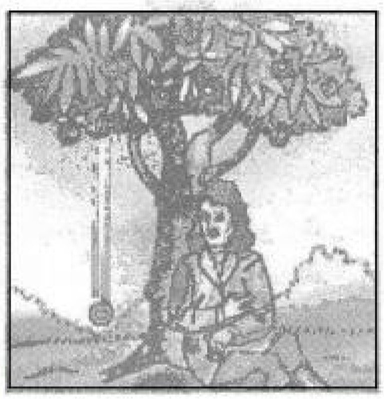




(a) Unloaded spring balance **(b) Loaded spring balance**

BRING TEAST

In principle, gravitational force acts between every two particle/bodies of mater in this universe. So if we take Newton's example of the falling apple, the apple should attract the earth as much as the Earth attracts the apple. So why doesn't Earth go up to meet the apple instead of the apple falling of meet the earth Find out



NEWTON'S LEW OF MOTION

NEWTONL'S FISRT LAW OF MOTION

A body at rest will remain at rest and a body in motion will remain in uniform motion unless an unbalanced forces acts on into change its state of rest of uniform motion.

THE ABOVE LAW CAN BE UNDRESTOOD IN TWO PARTS.

(i) A body at rest remains at rest unless an external unbalanced force acts on it change its state of rest.

Ex. Consider a wooden block kept on a horizontal at rest. It will remain at rest unless somebody moves it.

(ii) **A body in motion will remain in uniform motion unless an external unbalanced force acts on it to change is state of uniform motion**

INETIA

The tendency of a body to oppose any change in its state of uniform motion is called inertia of the body.

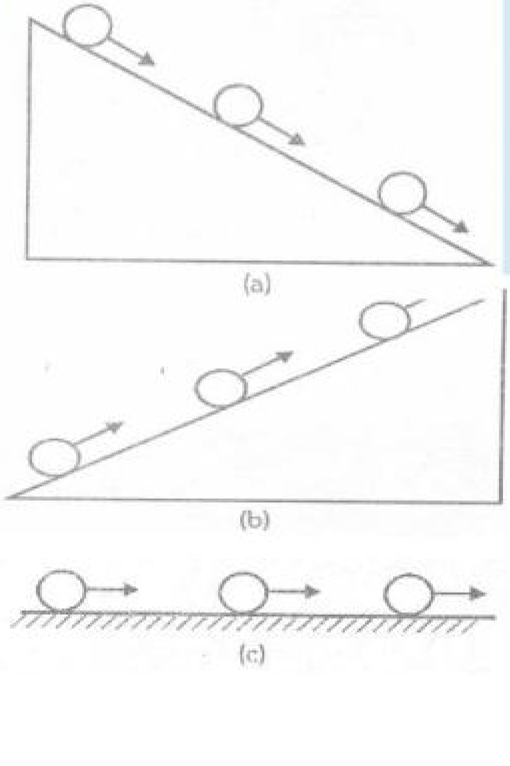
GALLIEOI'S LAW OF INETIA :

Galileo studied motion of object on an inclined plane. He found that

(i) object moving down a smooth inclined plane accelerate.

(ii) Object moving up a smooth inclined plane retard.

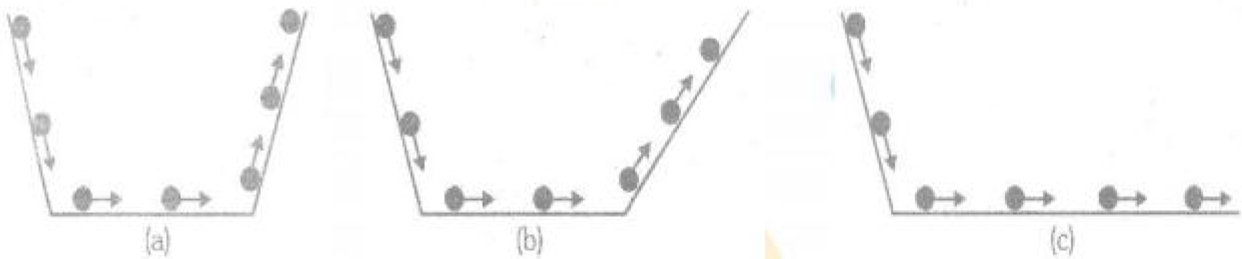
(iii) Object moving up a frictionless horizontal plane move with a constant velocity, having nether acceleration nor retardation.



In another experiment using a double inclined plane, Galileo observed that

A ball released from rest on one smooth inclined plane rolls down and climbs up the smooth inclined plane. He found that'

(i) In ideal situation, when there is no friction, the final height of the same as the initial height. In actual practice, when some friction is there, final height is somewhat less then the initial height. In no case, final height is ever garter then the initial height. When the slope of the two planes are same, distance covered in rolling down one incline is the same as the distance' covered climbing up the other incline. This is shown in fig.



(ii) When the slope of second smooth inclined plane is increased, and the experiment is repeated, the ball still reaches the same final height. But in doing so, it travels a large distance as shown in fig.

(iii) When the slope of second smooth inclined plane is made zero. (i.e. the second plane is made horizontal), the ball travels in infinity distance in the ideal situation (When there is no frication) i.e. motion or the ball never ceases.

From his experiments, Galileo concluded that the state of rest and the state of motion with constant velocity are equivalent. In both cases, no net force is acting on the body.

Galileo emphasized that it is incorrect to assume that a net force is needed to keep a body in uniform motion along a straight line.

Thus, Galileo concluded that. If net external force is zero, a body at rest continues to be at rest, and a body in uniform motion continues to moves uniformly along the same straight line. This Galileo's law of inertia.

This, inherent property of all bodies, by virtue of which they cannot change by themselves the their state of rest or of uniform motion along a straight line is called Inertia.

TYPE OF INEIA :-

(a) INERTIA OF REST

The resistance offered by body to change its state of rest in called inertia of rest.

or

It is the inability of a body to change by itself its state of rest. This means a body t rest remains at rest and cannot start moving on it own.

Example :

(i) When a branch of a tree is shaken vigorously, ripe fruits get detached and fall. This is because the branch comes in motion but the fruits at rest tend to remains at rest due to inertia of rest and get detached. After the fruits get detached, gravity plays its role in making the fruits fall.

(ii) For removing dust from a carpet, we hang the carpet and than beat it with a stick. Due to the beating action, the carpet moves along the stick and the dust particle, in a tendency to remains at rest, get detached from the carpet.

(iii) When you hit a striker on a pile of carom counters, you will observe that only the lowest counter moves away.

The rest of the pile remains in the original position.

(iv) If you hit a glass window with a bullet, Only a small hole is formed in the pane. The whole window does not break. This is because the time of contact of the bullet with the window pane is short. In this duration, the whole window does not come in motion. It remains at rest due to inertia of rest.

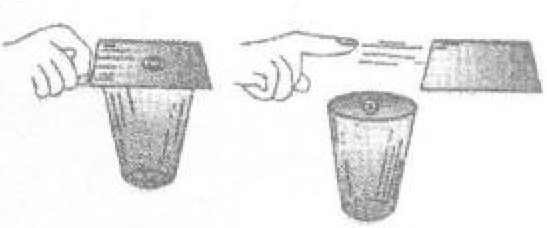
But if a stone hits the window pane, the time of contact of the stone with the pane is enough to shake the complete glass of the window. Therefore, the glass pane gets shattered.

(v) Suppose we are standing in a stationary bus and the driver starts the bus suddenly. We get thrown backward with a jerk. Let us understand why ?

(vi) When a hors starts suddenly, the rider tends to fall backwards on account of inertia of rest of upper part of the body as explained above.

ACTIVITY – 1

Whet happens when a quick jerk is given to a smooth thick carboard placed on a tumbler with a small coin placed on the cardboard ? The coin will fall in the tumbler. Why ?



The coin was initially at rest. When the cardboard moves because of the jerk, the coin tends to remain at rest due to inertia of rest. When the cardboard leaves contact with the coin, the coin falls in tumbler on account of gravity.

(b) INARTIA OF MOTION

The resistance offered by a body a change its state of uniform called inertia of motion.

or

It is the inability of body of change by itself its state of uniform motion. i.e. body in uniform motion can neither acceleration nor retared on it own and come to rest.

(i) An athlete runs for before taking a long jump.
The motion gained by the athlete help him to take a longer jump.

(ii) When we switch off a, it continues to rotate for a while due to inertia of motion.

(iii) A person jumping out a moving bus in the direction of motion of bus falls forwards. This is because when his foot touches the ground the foot comes, but the upper part of his body motion, tends to remain in motion.

(iv) Suppose we are standing in a moving bus, and the driver stops the bus suddenly. We are thrown forward with a jerk. Let us understand why.
As the bus is suddenly stopped, our feet stop due to fircation which does not allow relative motion between the feet and the floor of the bus. But the rest of our body continues to move forward due to inertia. That is why we are thrown forward. The restoring muscular forces exerted on our body by feet come into play and bring the body of rest.

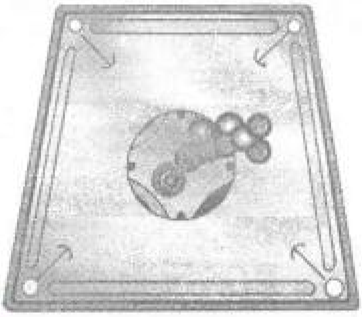
(v) When a horse at full gallop stops suddenly, the rider forward falls forward on account inertia of motion as explained adove.

(c) INERTIA OF DIRCTION

The resistance offered by to change its direction of motion called inertia of direction.

Or

It is the inability of body of change by itself its direction of motion i.e. body continues to moves along the same straight line unless compelled by some external force to change it.



Examples :

(i) When a bus suddenly taken a turn, the passengers sitting casually experience jerk in the outward direction.

(ii) Why are mudguard used over the wheel of a vehicle ? The is because the mud sticking in grooves of the tyre fly of tangentially when the wheel moves at a high speed. To protect the rider from this mud, mudguards are used.

(iii) Suppose a stone tied to a string is whirled around against in a circle. What happens when the string is cut ? The stone flies off tangentially due to inertia of direction.

(iv) While sharpening the edge of a knife, it is rubber against rotating grinding wheel., The sparks produced levas the grinding wheel tangentially due to inertia of direction.

(v) When a car rounds a curve suddenly, the person sitting inside is thrown outwards. This is because the person tries to maintain his direction of motion due to directional inertia while the car turns.

Application of Newton's First Law :

A body is said to be in translation equilibrium, when

(a) It is at rest or

(b) When it is moving with a constant velocity.

CONCEPT 1: A state of equilibrium means that a body must be at rest.

Equilibrium means that the acceleration is zero

CONCEPT :2 If no net force acts on body, then the velocity

LINEAR MOMETUM

DEFINITON :

The product of mass and velocity of a body is called Liner momentum, it is denoted by P.
Linear momentum = mass × Velocity

$$\boxed{\vec{P} = m\vec{V}}$$

The S.I. unit of linear momentum is kg m/s.

Note:

(i) **Liner momentum has a senses of direction. Therefore it is a vector quantity.**

(ii) The direction of linear momentum of a body at and instant is same as that of the velocity of the body at that instant.

(iii) A body moving in a curved path. the direction of velocity at a point is a tangent drawn at that point. Therefore the direction of linear momentum is also tangential as shown in the figure.

NEWTON'S SECOND LAW OF MOTION

Rate of change of momentum of a body is directly proportional to the external force applied on it and the change in momentum taken place in direction of force.

$$\vec{F} \propto \frac{d\vec{p}}{dt}$$

Or $\vec{F} = \frac{kd\vec{p}}{dt}$ where k is constant of proportionally

$$\vec{p} \propto m\vec{v}$$

$$\vec{F} = \frac{kd}{dt}(m\vec{v})$$

$$\boxed{\vec{F} = mk\frac{d\vec{v}}{dt} = km\vec{a}}$$

$$\frac{d\vec{p}}{dt} = \text{rate of change of velocity} = \text{acceleration } (\vec{a})$$

If k = 1 $\boxed{\vec{F} = m\vec{a}}$

$$\vec{a} = \frac{\vec{F}}{m}$$

Thus the second law interprets that the effect of the force on a body is to produce an acceleration in the body.

" The force may be defines as something which produces acceleration in the material body".

Newton's second law F = ma is most general SI unit of force is newton .

Note : (i) The direction of acceleration is same as that of force.
(ii) ma is not a force in itself. The sum of all the forces acting on body equals ma.

NEWTON'S SECOND LAW IN TERMS OF LINEAR MOMETUM

DEFINTION : The rate of change of momentum of a body with respect to time is directly proportional the external force acting on the body and takes place in the direction of force.

Suppose a body of mass m is acted upon by an unbalanced external force F which created an acceleration in the body. Let the initial velocity of the body be u. Let the force continues to act for a time interval t and the final velocity of the body be v. Then we can write.

$$F = ma = m\left(\frac{v-u}{t}\right) \Rightarrow F = \frac{mv-mu}{t}$$

Here, mv = Final momentum of the body (P_f)

mu = Initial momentum of the boby (P_i)

The mv – mu (= P_f - P_i) represents the change in momentum.

The change in momentum written as Δp and is called delta P.

$$\boxed{F = \frac{\Delta p}{t}}$$

UNIT OF FORCE

S.I system unit of force is Newton (N)

C.G.S system, unit of force is dyne.

1 dyne = 1 gram × cms^{-2}

$$\boxed{1N = 10^5 \text{ dyne}}$$

The unit of force is S.I. and C.G.S. system are called absolute units of force.

GRVAITATIONAL UNIT OF FORCE : The gravitational unit of force is not an absolute unit of force sine it gravitational units not.

The two gravitational unit are not.

The two gravitational units of force are kilogram weight (kg -wt) or kilogram force (kg -f), and gram weight (g - wt) or gram force (g - f)

At the surface of the Earth.

1 kg – wt = 1 kg × 9.8 m/s^2 = 9.8 kg m/s^2 = 9.8 N

1 g – wt = 1 g × 98 cms^2 = 98 cm/s^2

Caution : Sometimes we come across statements like the weight of the body is 5 kg. It means that the body is 5 kg – wt or 5 kg-f

$W = 5$ kg wt

$\Rightarrow \quad W = (5 \times g)$ N

$\Rightarrow \quad W = 5 \times 10 = 50$ N

SOME APPLICATION OF F = $\frac{\Delta p}{t}$

Example 1. A cricket player lowers hands while catching ball.

By doing so the player increases t, the time interval for the change in momentum. Because of this the force experienced by his hands is less.

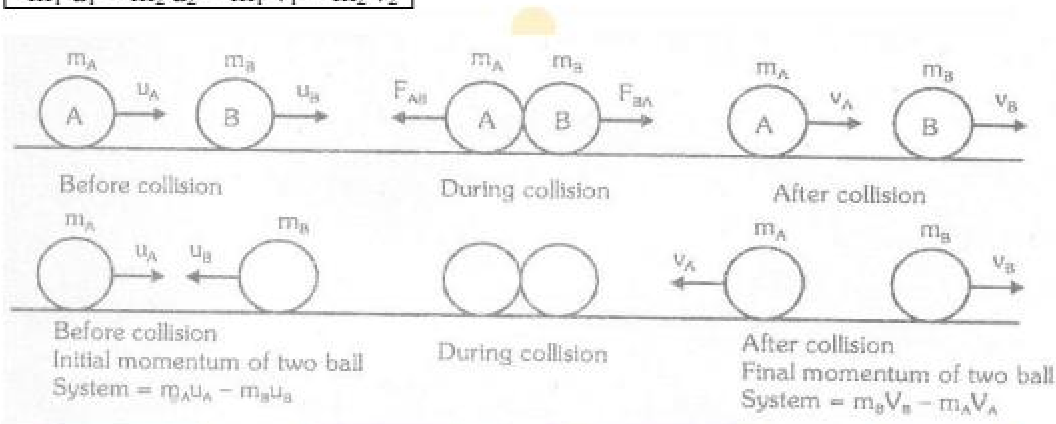
Example : 2. If you have seen a Karate player braking a pile of bricks with a single blow, you must have observed that the does this activity quite fast thereby reducing t. because of this a large of force F acts on bricks which is enough of break the pile of bricks.

LAW OF CONSERAVTION OF MTION

We know that if a moving body strikes a body at rest. the moving body slows and the stationary body starts moving. Whereas the first body loses momentum, the second gains momentum. We shell observe that the total momentum before impact is equal to total momentum after impact.

If two bodies of mass m_1, m_2 are initially moving with velocity u_1, u_2 and after collision they start moving with velocity v_1 and v_2 respectively, then

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$

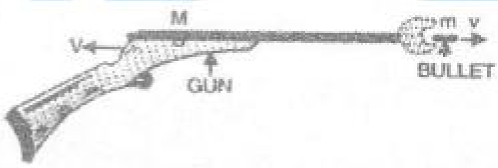


i.e. total momentum before collision is equal to total momentum after impact.

If one body gains momentum. the other loses an equal amount of momentum,

SOME ILLUSTARTION OF THE CONSERVATION OF MOMETUM

1. **RECOIL OF GUS** . The and the bullet constitutes a single system. Before the gun is fired, both the gun and the bullet are at rest so that – their total momentum is zero. As the gun is fired, the force of the exploded gun powder accelerates the bullet and given it a large forward velocity. The bullet in turn reacts upon the gun and causes it to recoil backward. Let the bullet of mass moves, forward with a velocity v and the gun of mass M kick backward with a velocity $\vec{V}$. According to the principle of conservation of momentum, the total momentum of both the bullet and the gun after the gun is must remain the same as it was before firing the gun i.e. zero.



Recoil of gun.

Thus

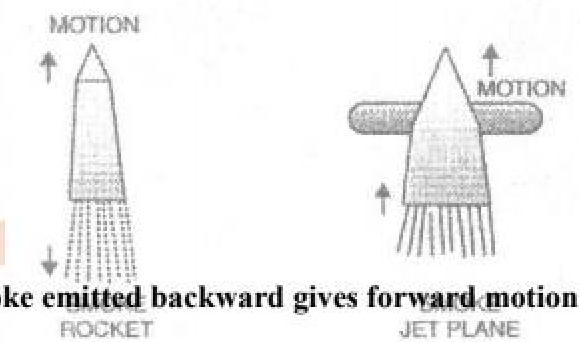
Final momentum = Initial momentum

- MV + mv = 0

MV = mv or $\vec{V} = \frac{m\vec{v}}{M}$

Thus, it is clear from the above equation that the velocity V of the gun is oppositely to velocity v of the bullet. Knowing v, m and M the velocity of the recoil determined.

2. **Rockets and Jet Planes.** The propulsion of rockets and jet plane is another very interesting application of the law of conservation of momentum. In both of them, the fuel (gasoline) and the oxidizer get mixed up in the combustion chamber where they undergo violent chemical reaction. The products of explosion, which are hot and highly compressed gases acquire a large backward momentum which, in turn, impart in equal and opposite momentum to the rocket.



Smoke emitted backward gives forward motion to rocket or jet plane

IMPULSE

The force which act on bodies for short time are called impulsive forces. Fox example :

(i) In hitting a ball which a bat.

(ii) In driving a nail into a wooden block a hammer

(iii) In firing a gun, etc.

An impulsive force does not remain const but changes first from zero to maximum and to from maximum to zero. Thus is not possible to measure easily value of impulsive becal it changes with time. In such cases, we measure total effect of the force, called impulse .

Hence impulse of a force is measure of the effect of the force. It is given by product of average force and the time of which the force on the body. i.e.

Impulse = average force × time

APPLICTIONS OF THE CONCEPT OF IMPULSE

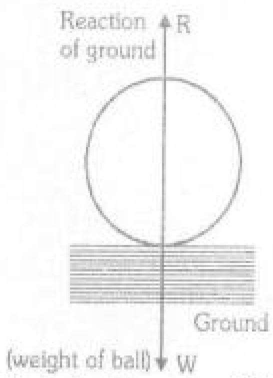
1. When a person falls from a carting floor does not yield. The total change in linear momentum is produced in a smaller interval of time. Therefore, as explained above, the floor exerts is a much large force. Due to it, a person receives more injiury.
2. On the other hand, when a person falls on a heap of sand. The sand yields. The same change in linear momentum is produced in much longer time. The average force exerted on the person by the heat of sand is, therefore, much smaller and hence the person is not hurt.
3. China wares and glasswares are wrapped in paper or strawn pieces before packing. In the event

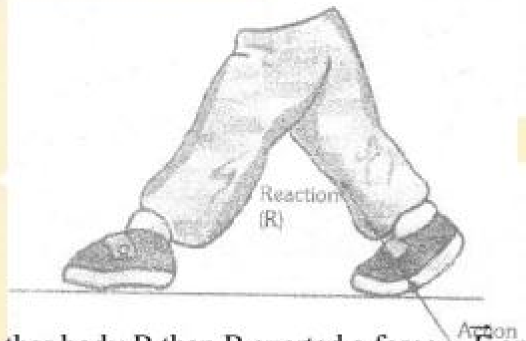
of fall, impact will take a longer time to reach the glass/chinawares through paper/straw. As a result, the average force exerted on the china or glasswares is small and chances of their breaking reduce.

4. The vehicles like scooter, car, bus, truck, etc. are provided with shockers. When they move over an uneven road impulsive force are exerted by the road. the function of shockers is increase the time of impulse. This would radius the force/jerk, experienced by the rider of the vehicle.
5. Bogies of train are provided with the but Ters. They avoid sever jerks during shunting of the train.
6. It is difficult to each a cricket ball then to catch a tennis ball. The cricket ball being heavier has much larger exerted by tennis ball.
7. In a road on collision between two vehicles, change in linear momentum is equal to sun of the linear momenta vehicles.
8. An athlete is advised to come to stop slowly, after finishing a fast race , so that of stop increase and hence force experienced by him decreases.

NEWTON'S THIRED LAW OF MOTION

DEFINITION : Each and every action, there is equal and opposite reaction.





If a body A exerts of force $\vec{F}$ on another body B then B exerted a force $-\vec{F}$ on, A the two force acting along the same line. The Two force $\vec{F}$ and $-\vec{F}$ connected by Newton's third law are called action-reaction pair. Any one may be called action' and the other 'reaction'

Action and reaction acts on different bodies hence they never cancel each other.

Note : Action and reactions forces occur simultaneously. It is wrong to think that first action occure and it is followed by reaction.

An important conclusion : when action- reaction force are acting on two bodies of masses m_A and m_B then

From eqn. $F_{AB} = F_{BA}$

$$m_A a_A = -m_B a_B$$

$$\frac{a_A}{a_B} = \frac{m_B}{m_A}$$

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

IMCONCPET : The action and reaction forces acting on a body are equal and opposite and therefore cancel out the effect of each other.

CONCEPT : Action and reaction do not cancel out the effect of each other because they act on different bodies.

MICONCEPT : Any pair of equal opposite force is a action – reaction pair.

CONCEPT : Only those-force from an action – reaction pair which involve the two bodies responsible for action reaction .

SOME OTHER EXAMPLE OF NEWTON'S THIRD LAW:

1. When a bullet is fired from a gun, we observer recoiling of the. The gun acts on bullet i.e. exerts a force on the bullet simultanecously, the reacts on the gun.

2. While walking or running, you push the ground in the backward direction with your feet. The ground simultaneously exertes a force equal magnified in the forward direction on feet. This force enables us to walk.

Fig. A running athlete

3. When a main jumps from a boat, the boat also experience a between jerk. This is due to the action –reaction pair as show in figure,

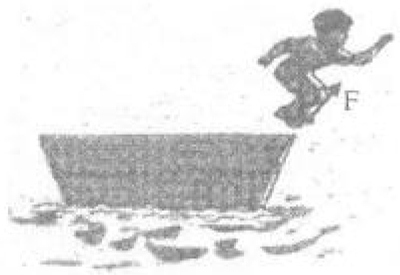
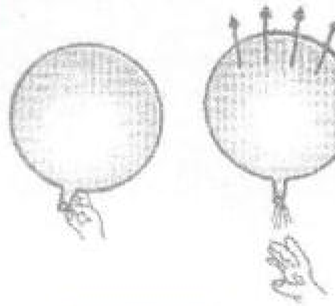


Fig. A jumping from a boat

4. Inflate of balloon and leave it. You will observe that the balloon moves in opposite direction to the opening in balloon through which the air is coming out.



THRMS TO MEMORISE

Newton's second law states that the force is proportional to the product of mass acceleration. Second definition of 2^{nd} law. The rate of change of momentum is proportional to the impressed force and takes place in the direction of force.

Force applied on a body is 1 N if it produces on mass of 1 kg an acceleration of m s^{-2}

Force applied on a body is 1 dyn if it produces on a mass of 1 kg an acceleration of 1 cm s^{-2}

$1\ N = 10^5$ dyn.

Momentum is the quantity of motion contained in body and is equal to product of mass and velocity It is measured in kg m s^{-1} in SI and in g cm s^{-1} in CGS.

Impulse is the product of force and time and is also equal to the change in momentum. Its SI unit is Ns or kg m s^{-1} CGS . it is measured in dyn s or g cm s^{-1}

IMPULSE DURING AN IMPACT OR COLLSION : The impulsive torce acting on the Doay proacuces a change in momentum of a body on which it acts. We know Ft = mv – mu, therefore the maximum force needed to produce a given impulse depends upon time, it me is short, the force required to produce a given impulse or the change in momentum is large and vice verse.

COMSIDER SOME OF THE EXAPLES BELOW

1. A person falling from a certain height receives severs injuries if he falls on a cemented floor then if he fall on a heap of sand. Although the change in momentum in both the cases in the same but time come to rest in the first case is smaller then that in the second case. Hence in first case (sudden stop on cemented floor). force applied against him is very large causing hi severs injuries.

2. China – wares are wrapped in paper or straw to avoid breakage. Due to fluffy nature of the pacing material, the time of impact between pieces of china waters is increase and hence of impact between them is reduced.
3. Bogies of the train are provide with buffers to increases the time of impact bogies stop. Hence the force of impact (and jerk) is reduced.
4. Antomoblies (cars, scooters, etc) are provided with spring system. When it runs on uneven surface, it receives jerks. The spring fitted to it increase the time of jerk and hence reduce the due to jerk.

REMEMBER

Unit of force is dyn or Newton whereas that of mass is gram of kilogram.

It is wrong to say "Weight' of Ankit is 40 kg. "We should" mass of Ankit is 40 kg of Weight of Ankit is $40 \times 9.8 = 392$ N.

1. metric ton = 1,000 kg, 1 quintal = 100 kg

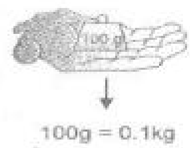
1 metric ton = 10 quintals 1 kg = 1, 000 g

GOLDEN RULES TO SOLVE NUMERICAL PROBLEMS

1. Read the problem slowly and with full concentration at twice.
2. Grasp the probem.
3. Think over it for 1 s to 20 s.
4. Write down the date of known quantities and quantities to be determined.
5. Select a formula containing known quantities and one unknown quantity at a time
6. Try to determine the other unknown quantity by selecting known and this unknown.
7. Try to solve the problem (if possible) with using the quantity determined in step
8. If there is no alternative, only then use result of step 6

IMPORTANT NOTE

1. In solving the numerical, always take the force in absolute unit i.e. in dynes or newtons.
2. $1 \text{ N} = 10^5$ dyn.
3. The kg (kilogram force) and kg wt (kilogram weight) are two names of same quantity i.e of practical units of force.
4. Momentum is a vector quantity
5. Weight of the body of force applied should be never stated in kg. Kilogram is unit of mass and not of weight of force. Never say, "My weight is 50kg." Sey "My weight is 50×9.8 N " or say, "My mass is 50 kg "
6. Hold 0.1 kg on your hand placed parallel to earth. Your hand is applying a force nearly 1 N (0.98 N to be exact).
7. In all numericals, use only absolution units (N or dyn.) It the force is given in kg f or g of , converts these to N or dyn.



SOLVED EXAMPLES

Ex. 1 Calculate the required to impart to a car, a velocity of 30 m s^{-1} . The mass of the car is 1,5000 kg.

Sol. Here u = 0 m s^{-1} ; V = 30 ms^{-1} ; t = 10 s ; a = ?

Using v = u + at, we have

30 = 0 + a (10)

Now F = ma = 1,500 × 3

Or F = 4.500 N

Ex.2 A cricket ball mass 70 g moving with a velocity of 0.5 stopped by player in 0.5 s What is force applied by player to stop the ball ?

Sol. Here m = 70 g = 0.070 kg; u = 0.5 m s^{-1} ; v = 0 ; t = 0.5 s

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

Or $$F = \frac{0.070(0-0.5)}{0.5}$$

Or F = 0.07 newton

Ex.3 What will be acceleration of a body mass 5 kg if a force of 200 N is applied to it ?

Sol. Here m = 5 kg ; F = 200 N

F = mg or a = F/m

$$a = \frac{F}{m} = \frac{200}{5} = 40 \text{ m s}^{-2}$$

a = 40 m s^{-2}

Ex.4 A bullet of mass 10 is fired from a rifle. The bullet takes 0.003 s to moves through its barrel and leaves with a velocity of 300 m s^{-1} What is the force on the bullet by the rifle ?

Sol. Here m = 10 g = 0.010 kg ; u = a ; v = 300 m s^{-1}

t = 0.003 s, F = ?

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

Or $$F = \frac{0.010(300-0)}{0.003}$$

Or F = 1, 000 N

Ex.5 What force would be needed to produce an acceleration of 1 m s^{-2} on ball of mass 1 kg ? **Sol.** Here m = 1 kg; a = 1 m s^{-2} ; F = ?

Now F = m a = 1 × 1

Or F = 1 newton

Ex.6 What is the acceleration produce by a force of 5 N exerted on an object of mass 10 kg

Sol. Here F = N ; m = 10 kg; a = ?

Now $F = ma$ or $a = \frac{F}{m}$

$$a = \frac{5}{10} = 0.5 \text{ m s}^{-2}$$

Ex.7 A car of mass 2,400 kg moving with a velocity of 20 m s^{-2} brakes. Calculate the retardation and retarding force.

Sol Here u = 20 + at we have

Using v = u + at, we have

$a = 20 + a(10)$ or $10a = -20$

$a = -2\ m\ s^{-2}$

Retardation = $-a = +2\ ms^{-2}$

Retardation force = $-ma = 2{,}400\ (-2) = 4{,}800$ N

Ex.8 How long should a force of 100 N act on a body of 20 kg so that it acquires a velocity of 100 m s^{-1} ?

Sol. Here $v - u = 100\ ms^{-1}$ m = 20 kg; F = 100 N ; t = ?

We know $F = ma = \dfrac{m(v-u)}{t}$

Or $t = \dfrac{m(v-u)}{F} = \dfrac{20(100)}{100} = 20$ s

Ex.9 A certain force exerted for 1.2 raises the speed of the object from 1-8 ms^{-1} to 4.2 ms^{-1} Later the same force is applied for 2 s. How much does the speed change in 2 s?

Sol Here u = 1.8 m s^{-1} v = 4.2 m s^{-1} ; t = 1.2 a = ?

Using v = u + at, we have

4.2 1.8 + a (1.2)

2.4 = 1.2 a

Or a = m s^{-2}

In second case, initial velocity u = 4.2 s^{-1} ; v = 7 ; t = 15 a = 2 m s^{-2} [Calculated above],

Using v = u + at, we have

$v = 4.2 \times 2 \times 2$

or $v = 8.2\ m\ s^{-1}$

$\therefore$ Increase of speed in 2s is = $8.2 - 4.2 = 4\ m\ s^{-1}$

Ex. 10 A 1,000 kg vehicle moving with a speed of 20 m s^{-1}brough to rest in distance of 50 m, (i) Find the acceleration (ii) Calculate the unbalanced force acting on the vehicle (iii) The actual applied by the brakes may be slightly less than that calculated in (ii) Why ? Give reason.

Sol (i) Here u = 20 m s^{-1} ; V = 0 ; s = 50 m; a = ?

Using $v^2 - u^2 = 2as$, we have

$$a = \frac{v^2 - u^2}{2s} = \frac{0-(20)^2}{2(50)} = -4\ ms^{-2}$$

(ii) $F = ma = 1{,}000 \times (-4) = -4{,}000$ N

(iii) Due to force of frication the actual force applied by brakes may be slightly lass than calculated one.

Ex.11 Which would grater force; acceleration a 10 g mass of 5 m s^{-2} or 20 g mass at 2 m^{-2} ?

Sol In first case $m_1 = 10\ g = \frac{10}{1,000} kg = 0.010\ kg$;

Now $a_1 = 5\ m\ S^{-2}$; $F_1 = ?$

$F_1 = m_1 a_1 = 0.010 \times 5$

$F_1 = 0.050$ newton

In second case $m_2 = 20\ g\ \frac{20}{1,000} kg$

Or $m_2 = 0.020\ kg$

$a_2 = 2\ m\ s^{-2}$ $F_2 = ?$

Now $F_2 = m_2 a_2 = 0.020 \times 2$

Or $F_2 = 0.04$ newton

We find that $F_1 > F_2$ hence more force is required to acceleration 10 g at than acceleration 20 g at 2 m s^{-2}

Ex.12 A truck starts from rest and rolls down a hill with constant acceleration. It travels a distance of 400 m in 20 s.

Find its acceleration. Find the force acting on it if its mass is 7 metric ton.

Sol Here $u = 0\ m\ s^{-1}$(Starting from rest) ; $s = 400$ m ;$t = 20$ s; $a = ?$

Using $s = ut = \frac{1}{2}at^2$

We have $400 = 0 + \frac{1}{2} \times a \times 20 \times 20 = 20\ a$

Or $a = 2\ m\ s^{-2}$

Now mass $m = 7$ metric ton $= 7,000$ kg $F = ?$

$F = m\ a = 7,000 \times 2$

$F = 14,000\ N$

Ex.13 A force of 5 N given a mass m_1, an acceleration of 8 m s^{-2} and a mass m_2 an acceleration of 24 m s^{-2}. What acceleration would it given if both the mass are tied together ?

Sol Let us first find mass m_1 and m_2

$F = m_1\ a_1$

$5 = m_1 (8)$ or $m_1 = 5/8$ kg

$F = m_2\ a_2$

$5 = m_2 (24)$ or $m_2 = 5/24$ kg

Total mass $M = m_1 + m_2$

Or $M = \frac{5}{8} + \frac{5}{24} = \frac{15+5}{24}$

Or $M = \frac{20}{24} kg$

Let A be the acceleration produced in mass M.

$\therefore$ $F = MA$

Or $5 = \frac{20}{24} A$

Or $\quad A = \frac{5 \times 20}{24} = \frac{120}{20} = 6 \text{ ms}^{-2}$

Hence the acceleration of the combination is 6 m^{-2}

Ex.14 A car of mass 1,000 kg moving with a velocity of 40 km h^{-1} collieds with a tree comes to stop in 5s what will be force exerted by car on the tree ?

Sol. Here $\quad m = 1,000$ kg

$$u = \frac{5}{18} \text{ms}^{-1} = \frac{100}{9} \text{ms}^{-1}$$

$$v = 0 \; ; t = 5 \text{ s}$$

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

Or $\quad F = \frac{10000(0-100/9)}{5}$

Or $\quad F = 200\left(\frac{-100}{9}\right)$

Or $\quad F = \frac{-20,000}{9}$

Or $\quad F = -2,222$ N

Ex.15 The velocity-time graph of a coin moving on a floor is as given in Fig. How much force does the floor exert on the coin ? Given the mass of the coin is 10 g.

Sol. Here $\quad u = 24 \text{ cm s}^{-1}$

$$v = 0 \text{ ms}^{-1} \; ; t = 8 \text{ s} \; ; a = ?$$

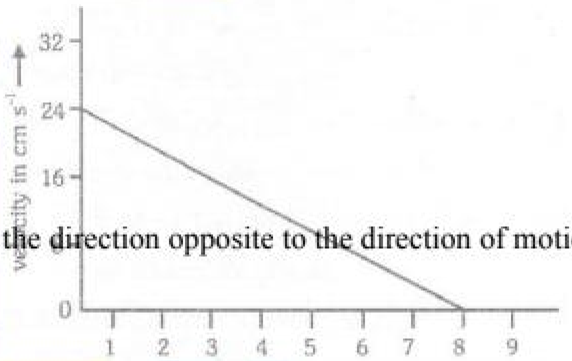
$$v = u + at$$

$$F = m\,a \; ;$$

Here $\quad m = 10$ g

$$F = 10\,(-3) = .30 \text{ dyn} = -30/(10^5) \text{ N}$$

Or $\quad F = -3 \times 12^{-4}$ N.



Negative sing tells us that the force is acting in the direction opposite to the direction of motion.

1. An external influence which change of tends of change the state of rest or uniform motion of body or its dimensions is called.
(A) momentum (B) force (C) momentum of force (D) pressure
2. Equal and opposite forces acing on a body which do not change its state of or uniform motion are called.
(A) like parallel force (B) unlike parallel force (C) balanced force (D) all the above
3. The unequal and opposite force acting on a body, which change its state of rest or uniform motion are called.
(A) unbalanced force (B) unlike parallel force (C) like parallel force (D) all the above
4. Force of friction always acts in the direction.
(A) of applied force (B) opposite to the direction of applied force
(C) at right angels to the direction of applied force (D) none of the above
5. When balanced forces act on a body, the body.
(A) must remain in its state of rest
(B) must continue moving with uniform velocity, if already in motion
(C) must experience some acceleration
(C) both (A) and (B)
6. When unbalanced forces at on a the body :
(A) must move with uniform velocity
(B) must remain at rest
(C) must experience acceleration
(D) must move in a curved path
7. If no external force acts on a body it will
(A) move with more speed
(B) change its shape
(C) break its shape
(D) either remain in its state of rest or in uniform motion.
8. If a body is allowed ti freely fall from a height, its speed increases continuously. It is because :
(A) air does not exert frictional force
(B) magnetic force of earth increases its speed

(C) gravitational force of earth increases its speed

(D) pressure of air force it downward

9. A force magnetic ‘F’ acts on a body of mass ‘m’ The acceleration of a body depends upon :

(A) volume of body (B) density of body (C) area of body (D) mass of body

10. Force remaining constant, if the mass of body increases, its acceleration is likely to :

(A) increase (B) remain same

(C) decrease (D) Sometimes increases and sometimes decreases

11. A force produces an acceleration ‘a’ in a body’ The same force produces and acceleration 4a in another body. The mass of other body is

(A) four times the mass of first body (B) four times less the mass of other body

(C) mass does not play role (D) none of the above

12. When a running motorbike accelerates suddenly, the pillion rider has a tendency to fall backward. This is an example of :

(A) Newton’s first law of motion (B) Newton’s second low of motion

(C) Newton’s third law of motion (D) Newton’s law of gravitational of motion

13. A force F acts on a stationary body for the time t. The distance covered by the body ‘S’ will be proportional to

(A) t (B) $\frac{1}{t}$ (C) t^2 (D) $\frac{1}{t^2}$

14. The impact which a body can broduce due to the combines effect of mass and velocity is called :

(A) momentum (B) frorce (C) moment of force (D) pressure

15. The SI unit of momentum is :

(A) newton (B) newton-second (C) dyne (D) dyne-second

16. The tendency of a body to continue in its state of rest or uniform motion. even on the application of external force is called :

(A) force (B) momentum (C) inertia (D) impulse

17 The tendency of body to continues is its state of rest of uniform motion even on the application of external the statement represents :

(A) Newton’s second law of motion (B) Newton’s first law of motion

(C) Newton’s third of law of motion (D) Law of conservation of momentum

18. The magnetic of inertia of a body is determined by its :

(A) mass (B) weight (C) velocity (D) acceleration.

19. Momentum is a :

(A) vector quantity (B) scalar quantity (C) fundamental quantity (D) none of the above

20. A body P has mass 2 m and velocity 5 v. Another body Q has mass 8 and velocity 1.25 v. The ratio of momentum of B and Q is :

(A) force (B) 1 : 1 (C) 1 : 2 (D) 3 : 2

21. The magnetic of a physical quantity is 8.5 Ns. The physical quantity is :

(A) force (B) momentum (C) pressure (D) moment of force

22. There is rubber ball and a stone ball of same size. If both balls are at rest :

(A) rubber ball has more inertia than stone ball

(B) stone ball has more inertia than rubber ball

(C) both have same inertia

(D) none of the above

23. When we vigorously a shake branch of a tree, some leaves at detached. It is due to the :

(A) inertia of rest (B) inertia of motion

(C) inertia of motion (D) none of the above.

24. When the driver of a fast moving car suddenly applies brakes, the passengers in the car :

(A) fall backward (B) fall forward

(C) are not affected (D) none of the above.

25. A spaceship continues moving in space with uniform speed because :

(A) no force of friction due to air acts on it (B) no force of friction due to earth on it.

(C) no force of gravitation acts on it (D) its mass is zero in space

26. A batsman hits a cricket ball. Which then rolls on a level ground. After covering a short distance, the ball comes to rest. The ball slows down to stop because :

(A) the batsman did not hit the ball hard

(B) velocity of ball is proportional to force acting on it

(C) there is force on the ball opposing its motion

(D) there is no unbalanced force on the ball and hence it comes to rest

27. The force of freely falling body is directly proportional to :

(A) mass of body (B) acceleration of body

(C) velocity of body (D) both (A) and (B)

28 The principle of conservation of linear momentum states that in a system it :

(A) cannot be changed

(B) can be changed. If inertia force act on it s

(C) can be changed. If external force act on it

(D) none of the above

29. Action-reaction force :

(A) act on same body (B) act on different bodies

(C) act along different lines (D) act in same direction

30. porter is carrying a weight of 200 N on his head. If the force exerted on his head taken as action, then the reaction force is exerted by :

(A) the heat on the weight (B) the weight on the earth

(C) the earth on the porten (D) the earth on the weight

31. hich of the following are vector quantities :

(A) momentum (B) velocity

(C) force (D) all of the above.

32. wo bodies collide at the time. Which of the following is conserved ?

(A) velocity (B) momentum

(C) kinetic energy (D) force

33. mpulse is equal to :

(A) the change in velocity (B) the change in momentum

(C) the change in velocity (D) all the above

34. rocket works on the principle of :

(A) conservation of energy (B) conservation of linear momentum

(C) conservation of inertia (D) conservation of force

35. hen a speeding car taken a sharp turn, the persons sitting in it experience of outward pull. This happens due to :

(A) inertia of motion (B) change in momentum

(C) change in acceleration (D) none of the above

36. he ratio of force and acceleration of a moving body is the measure of its :

(A) velocity (B) momentum (C) mass (D) impulse

37. hen you kick a stone, you get hurt. Due to which property this happens ?

(A) inertia of stone (B) velocity of the kick

(C) momentum of the kick (D) reaction of the stone

38. motor bikes acceleration on the horizontal road to the force exerted by :

(A) the engine of motorbike (B) the earth

(C) the driver on the motorbike (D) none of the above.

39. mpulse has same unit as that of :

(A) force (B) pressure

(C) momentum (D) momentum of force

40. By Newton's second law, the physical quantity which can be calculated, if we know the magnitude of force on a given mass is :

(A) velocity (B) momentum

(C) acceleration (D) none of the above

41. A body is moving with a constant momentum. The motion of the body is :

(A) uniform velocity (B) acceleration

(C) de-accelerated (D) none of the above.

42. cracker rest explodes into two equal parts. These parts will move in :

(A) opposite direction with same velocity (B) same direction with different velocity

(B) same direction with same velocity (D) opposite direction with same velocities

43. A batsman has a choice to use heavy or light bat, while facing a fast bowler. He will prefer :

(A) light bat, because handling it is easy (B) heavy bat, so that he can handle firmly

(C) heavy bat, because it will recoilless (D) none of the above.

44. A vehicle has a mass of 1500 kg. If the vehicle is to be stopped with a negative acceleration of 1.7 ms^{-2}, the force of frication between the vehicle and road is :

(A) -2250 N (B) -2050 N

(C) -2250 N (D) none of the above.

45. A man while running at a constant acceleration of 3.5 develops a force of 280 N . The mass of man is :

(A) 80 kg (B) 85 kg (C) 75 kg (D) 60 kg

46. The mass of an aeroplane is 2.5 t. Its engine develop a force of 8750 N force taking off. The acceleration of the aeroplene at the time of take off is :

(A) 3.45 cm^{-2} (B) 3.65 ms^{-2} (C) 3.50 ms^{-2} (D) 3.60 ms^{-2}

47. A horse while running at a constant velocity of 15 ms^{-1}, develop a momentum of 300 Ns. The mass of horse is :

(A) 180 kg (B) 300 kg (C) 200 kg (D) 250 kg

48. A boy of mass 30 kg while running at constant velocity has a momentum of 180 Ns. The constant velocity of the boy is :

(A) 3 ms^{-1} (B) 6 ms^{-1} (C) 18 ms^{-1} (D) 12 ms^{-1}

49. An electric of mass 9×10^{-31} kg is moving in a straight line path with a velocity of 6×10^{7} ms^{-1}. The momentum of electric is :

(A) 5.4×10^{-23} Ns (B) 5.4×10^{-24} Ns

(C) 4.5×10^{-23} Ns (D) 0.5×10^{-24} Ns

50. A bullet of mass 0.10 kg is fried from a rifle. The bullet takes 0.003 s to moves through the barrel and leaves with a velocity of 300 ms^{-1}. The acceleration acting on the bullet is :

(A) 10,000 ms^{-1} (B) 100,00 ms^{-2} (C) 1000,000 ms^{-2} (D) 100 ms^{-2}

51. A truck stares of from rest and rolls down the hill with a constant acceleration. It travels 400 m in 20 s. If the mass of trucks is 7 metric tones, the acting on it is :

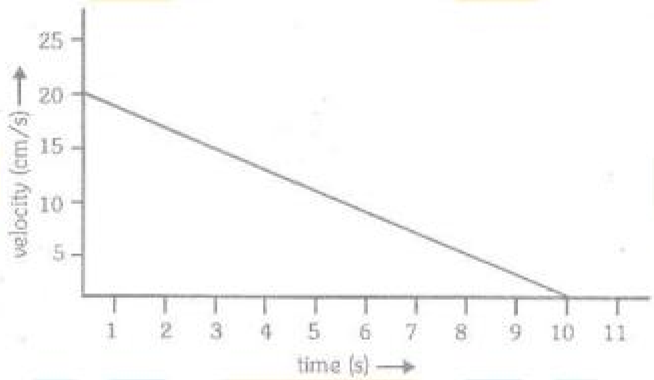
(A) 28,000 N (B) 14,000 N (C) 14000 N (D) 24,000 N

52. A 8000 kg engine pulls a train of 5 wagons, each of 200 kg along a horizontal track. If the engine exerts a force of 40,000 N and track offers a friction of 5000 N then net accelerating force acting on system is :

(A) 45,000 N (B) 40,000 N (C) 35,000 N (D) none of the above

ANSWER KEY															
Qus.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	B	C	B	B	D	C	D	C	D	C	B	A	C	A	
Qus	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	C	B	A	A	B	B	B	A	B	B	C	D	A	B	C
Qus.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans.	D	C	B	B	A	C	D	B	C	B	D	C	C	A	C
Que.	46	47	48	49	50	51	52								
Ans.	C	B	A	D	B	B	C								

1. A constant force acts on an object of mass 5 kg of for a during of 2 s. It increase the object's velocity from 3 m s^{-1} to 7 m s^{-1} . Find the magnetic of the applied force. Now if the force was applied for a duration of 5 s, what would be the final velocity of the object ?
2. Which would required a greater force – acceleration a 2 kg mass at 5 m s^{-2} or a kg mass at 2 m s^{-1}
3. A motorcar is moving with a velocity of 108 kg/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 passenger is 1000 kg.
4. A force of 5 givens a mass m_1, an acceleration of 10 ms^{-1} and a mass m^2, an acceleration of 20 m s^{-2}. What acceleration would it given of both the mass ware tied together ?
5. The velocity-time graph of ball of mass 2 g moving along a straight line of a long table is given in Fig 9.9 How much force does the table exert on the ball to bring to rest ?



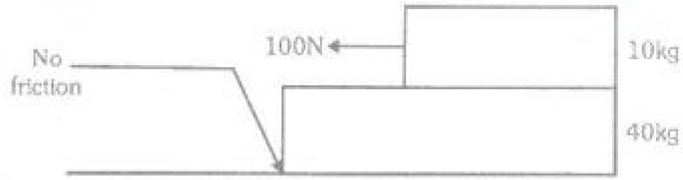
6. A bullet of mass 20 g is horizontal fired with a velocity 150 ms^{-1} from a piston mass 2 kg,. What is the recoil velocity of the piston ?
7. A girl of mass 40 kg jumps with a horizontal velocity of 5 ms^{-1}onto a stationary cats with frictionless wheels. The mass of the carts is 3 kg what is her velocity as the cart stars moving ? Assume that there is not external unbalanced force working in the horizontal direction.
8. Two hockey players of opposite teams, while trying to hit a hockey ball on the ground collide and immediately become entangled. One has mass of 60 kg and was moving with a velocity 5.0 m s^{-1} while the other has a mass of 55 kg and was moving faster moving faster with a velocity 6.0m s^{-1} towards

first player. In which direction and with what velocity will they move after they become entangled ? Assume that the frictional force acting between the feet of the two players and ground is negligible.

9. A body of mass 300 gm is at rest. What force in Newton will you have to apply to move it through 200 cm in 10 sec ?

10. A both of mass 3000 kg initially at rest is pulled by a force of 1.8×10^4 Newton through a distance of 3 m. Assuming that the resistance due to water is negligible, What is the velocity of boat ?

11. A 40 kg slab rests on a frictionless floor. A 10 kg block rests on top of the slab. The static coefficient of friction between the block and the slab is 0.60 while the kinetic coefficient is 0.40. The 10 kg block is acted upon by horizontal force 100 N. If g = 9.8 m/s^2, then what resulting acceleration of the slab will be



12. A stone of 1 kg is thrown with a velocity of 20 across the frozen surface of lake and comes to rest after traveling a distance of 50m. What is the force of frication between the stone and the ice ?

13. A 8000 kg engine pulls a train of 5 wagons, each of 2000 kg, along a horizontal track. If the engine exerts a force of 40000 N and the track offers a friction force of 5000, then calculate :

(A) the net acceleration force :

(B) the acceleration of the train; and

(C) the acceleration of the train : and

(D) the force of wagon 1 on wagon 2 .

14. An automobile vehicle, has a mass of 1500 kg, What must be the force between the vehicle and road if the vehicle is to be stopped with a negative acceleration of 1.7 m s^{-2}

15. What is the momentum of an object of mass m, moving with a velocity ?

(A) $(mv)^2$ (B) mv^2 (C) 1/2 mv^2 (D) mv

16. Two object. each of mass 1.5 kg are moving in the same straight line but in opposite directions. The velocity of each object is 2.5 m s^{-1} before the collision during which they stick together. What will be velocity of the combined object after collision ?

17. A hockey ball of mass 200 g traveling at 10 m s^{-1} struck at by a hockey stick so as to return it along its original path with a velocity at 5 m s^{-1}Calcualte the change of momentum occurred in the motion of hockey ball by the force applied by the hockey stick.

18. A bullet of mass 100 g traveling horizontally with a velocity of 150 m s^{-1} strikes a stationary wooden block and comes rest in 0.03s. Calculate the distance of penetration of the bullet the. Also calculate the magnitude of the force exerted by the wooden block on the bullet.

19. An object of mass 1kg traveling in a straight line with a velocity of 10 m s^{-1} collides with and sticks to, a stationary wooden block of mass 5 kg. Then they both move off together in the same straight line. Calculate the total momentum just before the impact and just after the impact. Also, calculate the velocity of the combined object.

20. An object of mass 100 kg is acceleration uniformly from a velocity of 5 m s^{-1} in 6 s. Calculate the initial and final momentum of the object. Also, find the magnitude of the force exerted on the object

21. How much momentum will a dumb-ball of mass 10 kg transfer to the floor if it falls from a height of 80 cm ? Take its downward acceleration to be 10 m s^{-2}

22. An object experience a net zero external unbalanced force. Is it possible for the object to be traveling with a non-zero velocity ? If yes, state the conditions that must be placed on the magnetic and direction of the velocity. If no, provide a reason.

23. When a carpet is beaten with a stick, dust out of it, Explain.

24. Why it is advised to tie any luggage kept on the roof of a bus with a rope ?

25. Explain with example Newton's First second Third Law's of motion.

ANSWER KEY

1. $v = 13$ m/s
2. acceleration a 2 kg mass at 5 ms^{-2} would require a greater force.
3. -7500 N
4. 6.67 m/s^2
5. -0.0004 m
6. $v = -1.5$ m/s
7. 4.65 m/s
8. -0.26 m/s
9. 0.12 m/s
10. 6 m/s
11. 0.98 m/s^2
12. -4 N
13. (i) 35000 N (ii) 3.5 m/s^2 (iii) 28000 N
14. 2550 N in a direction opposite to the motion of the vehicle
15. (D)
16. 0 m/s
17. 3 kg m/s
18. 2.25 m, 50 N
19. 10 kg m/s, 10 kg m/s, $\frac{5}{3}$ m/s
20. 500 kg m/s, 800 kg m/s. 50 N
21. 40 kg m/s

Important Notes