VIDEO.1:Momentum Conservation. VIDEO.2: Why hands drawn back.

# 3. MOTION & LAWS OF MOTION

**Balanced forces**.

It is when force is applied objects at rest are moved. But all forces do not make motion. On the basis of this, forces are classified into balanced force and unbalanced force. If total force or resultant force on a body is zero,the applied forces are called balanced force. Balanced forces cannot make change in the state of motion of an object.

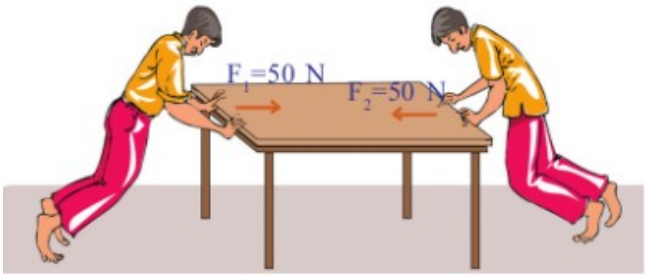



Fig.1

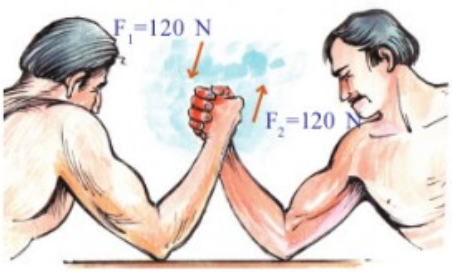



Fig.2

Examples for balanced forces are shown above.

**Motion and Laws of motions.**

Only an unbalanced external force can make change in the state of motion of an object. But a body in motion doesn't need an external force to continue in its state of rectilinear uniform motion.

**Newton's First Law of motion.**

Every object continues in its state of rest or of uniform motion along a straight line unless an unbalanced external force acts on it.

That is,velocity of an object will be remained constant until an unbalanced external force acts upon it.

**Inertia:**Inertia is the inability of a body to change its state of rest or of uniform motion along a straight line by itself.

Inertia of rest: It is the inability of a body to change its state of rest by itself.

Inertia of motion: It is the inability of a body to change its state of motion by itself.

The following are due to the inertia of rest:i.When a vehicle moves suddenly from rest, the standing passengers tend to fall backward. ii. When a branch of a tree is shaken, fruits fall down.

Examples for Inertia of motion: i.A running athlete cannot stop himself abruptly at the finishing point.

ii. The forward fall of standing passengers when a moving vehicle is suddenly stopped.

Inertia of an object depend on its mass. Inertia increases with mass.

That is why i. It is difficult to push aside a massive objects and ii. It is difficult to stop down a heavy moving object.

**Momentum:**Moving objects can make impact on another object. The effect of the impact depends on many factors. Momentum is a characteristic property of moving object. It is measured as the product of mass and its velocity. That is, momentum, p = mv

Momentum is a vector quantity. Its unit is kg m/s .

**Newton's second Law of motion.**

Force is a physical quantity that can make acceleration/change in velocity of an object. Second law is used to calculate force.

The rate of change of momentum of a body is directly proportional to the unbalanced external force acting on it.

That is, F = Constant x(mv – mu)/t = km(v-u)/t = kma

Since k = 1, **F = ma**

That is, force acts on an object is equal to the mass of the object and acceleration produced on it.

**Impulse and impulsive force**.

Impulsive force is a very large force acting for a very short time. Hammering on a nail, batting etc. are examples for applying impulsive force.

The product of impulsive force and time is called impulse. It is also equal to change in momentum.

Impulse = F.t = mv – mu

The unit of impulse is 'N s' .

From the equation of impulse, it is seen that if the change in momentum is constant, Impulsive force and time are inversely proportional.

That is, for making a certain change in momentum, the applied force can be reduced by extending time.

Very often this fact is made in use of our daily life.

Example:1. Reduce impact on the hands while catching fast moving ball by moving the hands backward.

Explanation:- Suppose a ball of mass 200 g is moving with a speed of 25 m/s. Let us calculate the force needed to stop it /reduce the momentum to zero.

Initial momentum of the ball = mu = $200x10^{-3}x25$ = 0.5 kgm/s

Final momentum of the ball = mv = 0

Change in momentum = 0.5 kgm/s

Force required to stop the ball in 0.1 s

= change in momentum/time = 0.5/0.1 = 5N

If time is extended to 0.5 s by moving hands with the ball, Required force = 0.5/0.5 = 1N

That is, when time is extended by moving hands backwards, force is decreased too much and hence impact on the hands is reduced.

Example:2: Sand is filled in highjump&long jump pit, Hay,sponge or thermocol is used while packing glasswares and tiles.

When the athlete falls down and hits the ground with loose sand, his body continues its motion through the soil some more time instead of coming to rest instantly. Thereby increase the time taken for reducing the momentum to zero and this leads to minimise the impact from the ground.

**Newton's third law.**

According to third law, forces always occur in pairs.

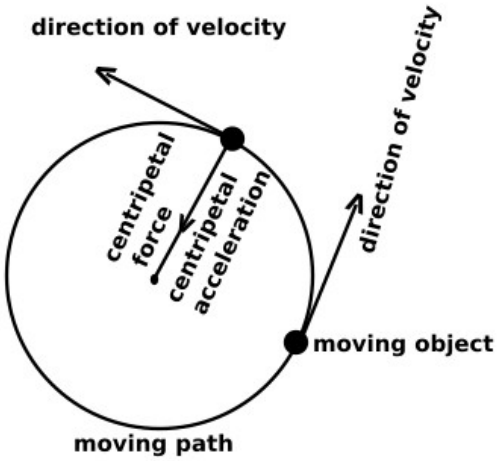
That is,*To every action there is an equal and opposite reaction.*

**Law of conservation of momentum**.

In the absence of an external force, the total momentum of a system is a constant.

**Circular motion**.

The motion of an object along a circular (curved) path is called circular motion. Movement of swing, movement of the tip of the hands of watch, movement of the pendulum of clock etc are examples for circular motion. If the speed of the object in circular motion is uniform, the motion is called uniform circular motion. The movement of the tip of the hands of watch is an example for uniform circular motion.




Though the speed of the object in uniform circular motion is uniform, its velocity is not uniform as the direction of motion is being changed continuously. That is, uniform circular motion is an accelerated motion. This acceleration is called centripetal acceleration and the force responsible to this acceleration is called centripetal force. The direction of centripetal acceleration and centripetal force will be towards the centre of the circular path along the radius.

Centripetal force, $F_c = mv^2/R$

## LAWS OF MOTION- PRACTICE QUESTIONS

1. Classify the following situations that related to balanced force and unbalanced force.
a. Mango falling down from the tree.
b. Rolling of a ball along the ground.
c. An object moves along a straight path with constant speed.
d. A box kept on a table.
e. An object is in uniform circular motion.
f.A stone projecting up.

**Ans. a.** Mango falling down from the tree. - Unbalanced force.
b. Rolling of a ball along the ground. - Unbalanced force.
c. An object moves along a straight path with constant speed – Balanced force.
d. A box kept on a table. – Balanced force.
e. An object is in uniform circular motion. - Unbalanced force.
**f.**A stone projecting up. - Unbalanced force.

2. You cannot push aside a car by standing inside it.
a. Can you explain why?
b. By which law can this be explained?
c. State the law.

**Ans**.a. Because there is no external force on the car. (In order to move an object at rest, an unbalanced external force is to be applied on it.)
b. First law.
c. Every object continues in its state of rest or of uniform motion along a straight line unless unbalanced external force acts on it.

3. What is inertia? What is the relation between mass and inertia?

**Ans**. Inertia is the inability of a body to change its state of rest or of uniform motion along a straight line by itself. Inertia increases with mass.

4. Identify the type of inertia in the following situation.
a. When a moving bus is suddenly stopped, the passengers tend to fall forward.
b. Falls forward when getting out from a running train.
c. Mangos fall down when the branch of a tree is shaken.
d. A runner cannot stop himself abruptly at the finishing line.
e. Small animals run zig zag path to escape from predators - Inertia of motion.

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5. Momentum is the characteristic property of moving objects.
a. What are the factors influencing momentum?
b. Write down the equation for momentum.
c. A car of mass 1000 kg is parked at the roadside. What will be its momentum?
d. A stone of mass 2 kg hits on a floor with a speed 30 m/s. Calculate the momentum of the stone when it just hit the floor.

**Ans**.a. Mass and velocity. b. Momentum, P = mv
c. Since velocity is zero,momentum P = 1000 x 0 = 0
d. Momentum P = 2x30 = 60 kgm/s

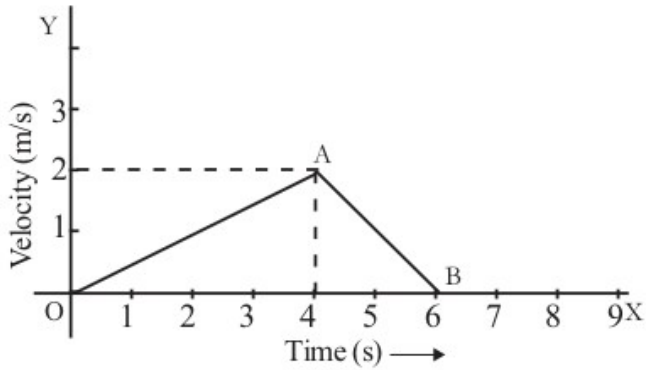
6. “When brake was applied to a Lorry with load it came to stop after moving 2m. If the lorry were empty and the speed was same as before, it would move more than 2m.” Comment to this statement.

**Ans**. This statement is false. When the lorry is empty, its inertia of motion (tendency to continue its motion) will be less than that before. So it will move a distance less than 2m before come to rest.

7. The speed of a vehicle of mass 2000 kg travelling along a straight road is changed from 15 m/s to 10 m/s . Calculate the change in momentum of the vehicle.

**Ans**. Change in momentum = Final momentum – Initial momentum = 2000x10 – 2000x15 = - 10000 kgm/s

8. A large force acting for a short interval of time is called impulsive force.
a.Give two examples for impulsive force.
b. How is the impulse of a force calculated?
c. What is the unit of impulse?
**Ans**.a. Kicking football, Hammering on a nail .
b. Impulse = Impulsive force x time = Fxt c. N s
9. Which is the law that is also known as law of inertia?
**Ans**. First law.
10. Newton's second law of motion helps to measure force.
a. State the law. b. Write down equation for finding out the force using this equation.
c. When a force was applied to an object of mass 5 kg, it got an acceleration of 4 $m/s^2$ . Calculate the force applied on the body.
**Ans**.a.The rate of change of momentum of a body is directly proportional to the unbalanced external force acting on it.
b. Force = mass x acceleration = ma
c. F = ma = 5x4 = 20 N.
11. Which law of motion is made in use of Rocket launching? State the law.
**Ans**. Newton's third law:- To every action there is an equal and opposite reaction.
12. A person cannot push aside a car by standing on a slippy surface. What might be the reason?
**Ans.** Because he doesn't get reactive force from slippy surface as there is no friction.
13. Velocity – time graph a moving object of mass 2 kg is give.
a. Find momentum of the object at $4^{th}$ second.
b. What is the acceleration of the object during first four seconds?
c. Calculate the force applied then.
d. Find out the displacement of the object during 6 seconds.




**Ans**.a.P =mv = 2x2=4 kgm/s
b. Acceleration= $(v - u)/(t_2 - t_1) = (2-0)/(4-0) = 0.5\ m/s^2$.
c. Force, F = ma = 2x0.5 = 1 N
d. Displacement = Area of the triangle OAB
= ½ bh = ½ x6x2 = 6 m
14.It is the centripetal force which keep up the object in uniform circular motion in its circular path.
a. Give an example for uniform circular motion.
b. What is the direction of centripetal force?
c.Write down the expression for centripetal force and specify the variables in it.
**Ans**.a. The movement of the tip of the hands of a watch.
b. To the centre along the radius.
c. Centripetal force $F_c = mv^2/r$ m – mass , v – velocity, r – radius of the path.
15. What is called the acceleration produced by the centripetal force? What is its direction?
**Ans**.i. Centripetal acceleration. It direcs towards the centre of the circular path along the radius.
16. Loaded heavy vehicle cannot be stopped abruptly by applying brake. Why?
**Ans**. The mass of loaded vehicles will be large. So inertia of motion (tendency to continue its motion) will be greater.
17."In the absence of an external force, the total momentum of a system is a constant" Identify the law.
**Ans**. Law of conservation of momentum.
18. What are the forces and their directions on a brick kept at rest on a horizontal surface. How do the forces relate?
**Ans**. i.Weight acting vertically downward ii. Upward normal reaction from the surface.
These forces are equal and opposite.

19. We can push aside a vehicle by standing on a road, even though the action and reaction are equal and opposite. How will you explain this?

**Ans**.They do not cancel each other as they are acting on two different objects.

20. "The velocity of an objects in uniform circular motion is uniform." Comment to this statement.

**Ans**. This statement is false. As the direction of motion of an object in uniform circular motion changes continuously, the direction of velocity also changes. So velocity is not uniform. But the speed is uniform.

21. When a force is applied to a body of mass 3 kg for 4 s, its velocity is changed from 3 m/s to 7 m/s. Calculate the force.

**Ans**. mass = 3 kg acceleration, $a= (7 – 3)/4 = 1\ m/s^2$.

Force, F = ma = 3x1 = 3 N.

22. Force is the physical quantity that can produce acceleration on an object.

a. Only a ..... can produce an acceleration on an object. (balanced force/unbalanced force)

b. The forces experienced on a book lying on a table are .....
(balanced force/unbalanced force)

c. A definition for force is obtained from newton's ..... law.
(First/second/third)

**Ans**.a. Unbalanced force.

b. Balanced force.

c.Second.