In our everyday life, we observe that some efforts are required to put a stationary object into motion or to stop a moving object.

Force: When you push a chair, it tends to move. To pluck an apple from a tree. You pull towards yourself. Hence we exert FORCE on that object. This also means that force has direction. Also, you push or pull an object gently or hard. This means force has a magnitude.

Any action which causes pull, hit or push on a body is called force. Force cannot be seen but it can be judged only by the effects which it produces in various bodies around us. Many effects of force are:

1. A force or set of forces can move a stationary body.
2. A force or set of forces can stop a moving body
3. A force or set of forces can change the direction and speed of a moving body.
4. A force or set of forces can change the shape and size of a body.

The SI unit of force is Newton "N".

Examples: When you apply the brakes in your bicycle, you are changing its velocity. Similarly, suppose you press the bulb of a dropper. You are producing a change in the shape of the bulb

Balanced and Unbalanced Forces: When the net effect produced by number of forces acting on a body is zero, then the forces are said to be balanced forces. If the two forces balance each other, they must be in opposite direction and have equal magnitude. For e.g., In a tug or war, when both the teams apply similar force from either sides, rope does not move, that is the resultant force is zero. Hence, it's a balanced force.

When the net effect produced by a number of forces acting on a body is non-zero, then the forces are said to be unbalanced forces. For e.g., a boy pushes the refrigerator with a small force, the refrigerator does not move due to friction force acting in opposite direction to the push. If he pushes harder, the pushing force becomes bigger than friction force; the refrigerator starts moving in the friction of push.

If unbalanced force acts on a body, the body will undergo change in its velocity. The body will accelerate.

Friction: Two bodies placed in contact can also exert force parallel to the surface in contact. Such a force is called force of friction, frictional force or Friction. The effect of friction is to oppose the slipping of two bodies against each other. Friction is small if surface is smooth. The friction is large if surfaces are rough.

Weight: The Earth attracts all bodies towards its centre. The force exerted by the Earth on a body is called the weight of the body. This force acts towards the centre of earth that is vertically downward direction. If the mass of body is "m", placed on the surface of earth, then Weight = m X g, where g= acceleration due to gravity = 9.8 m/sec^2 or 10m/sec^2

Galileo's Experiment: In the 16th Century AD, Galileo Galeli performed a very interesting experiment. He placed a ball on a very smooth surface.

- A ball starts from a height "h" from one end.
- It reaches the same height on the other end if we have a perfectly frictionless surface. Even if we reduce slope, it still reaches the same height
- It will move until it reaches be same height.

Observation: Galileo observed that body moves with uniform velocity if no force acts on it.

Newton's First Law of Motion: All the facts taken from Galileo law of inertia or Newton's first law of motion. The ideas suggested by Galileo and were formulated into law by Newton. Newton's First law: "a body at rest will remain at rest and a body in motion will remain in uniform motion unless acted upon by an unbalanced force."

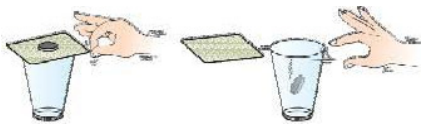
Inertia: The inability of a body to change on its own its state of rest or uniform motion is known as inertia. It is an inherent property of all objects. Inertia of an object is measured by its mass. Inertia is directly proportional to the mass. It means that inertia increases with increase in mass and decreases with decreases in mass. A heavy object will have more inertia than a lighter object.

Examples of Newton's First Law:

1. Inertia at rest: if we keep a body at rest, it remains there for any length of time is no force is applied on it.
2. Jerks while travelling: when we stand in a bus and the bus starts suddenly, we tend to fall backward. This is because our feet are in contact with the floor of the bus and the friction at the contact is high. This force does not allow the feet slip on the floor. The feet move forward with the floor. The upper body does not feel the forward immediately and remains at rest for a while. So, the upper part of our body gets jerked backward.

Similarly, when the bus stops suddenly, the feet come to rest immediately, but the upper body continues to move in forward direction. So, we tend to fall forward.

3. Card Coin experiment: Place a coin a smooth card kept on a glass as shown. Flick the card sharply in the horizontal direction. The card flies away and coin drops into the glass. Observation:



by applying force the card is accelerated and moves away. Since the friction between card and coin is negligible, there is no force on the coin in the horizontal direction. It remains in its original position due to inertia of rest.

Q: Why do blades of electric fan continue to rotate for some time after the current is switched off?

Newton's Second Law of Motion: Force is the cause of acceleration. If you push a body harder, large acceleration is produced. If we denote the magnitude of Force by "F" and acceleration by "a", then $F \propto a$; provided that forces are exerted on the same body that is mass is fixed. If you try to produces same acceleration in two objects of unequal masses, we need bigger force to accelerate the bigger object and smaller force to accelerate the lighter object. Then, $F \propto m$.

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Newton's Second law: "the magnitude of the net force acting on a body is proportional to the product of the mass of the body and its acceleration. The direction of the force is the same as that of the acceleration." F = k m a; where k is a constant.

Linear Momentum: The product of the mass of a body and its velocity is called the linear momentum of the body. If "m" is the mass and "v" be the velocity of a body at some instant, the linear momentum "p" is : p = m X v

The SI unit is kg m/sec.

Newton's Second Law in terms of Momentum

Newton's Second law: "the rate of change of momentum of an object is proportional to the net force applied on the object. The direction of the change of momentum is the same as the direction of the net force."

If a body of mass "m" moving at initial velocity "u" accelerates uniformly with an acceleration "a" for time "t" , so that its final velocity changes to "v", then:

Initial momentum p_1 = m X u;

Final momentum p_2 = m X v:

Change in momentum = p2 - p1 = m v - m u = m (v-u)

According to second law of motion: ∝ Force Change in momentum / time

F ∝ $(p_2 - p_1) / t$

F ∝ m (v - u) /t

F ∝ m a

F = k m a ; k is the proportionality constant.

When the force is zero, then the acceleration "a" is also zero and the body remains in its state of rest or of a uniform motion.

Sports and Second Law of Motion

1. A cricket player or fielder moves his hands backward while catching a fast cricket ball. This allows the fielder to catch the ball by applying a small force on it. If you keep your arms still while catching, the fielder has to apply a larger force on the ball. When we pull arms back with the ball. We apply a smaller force for a longer time. This is because the ball stops completely only when the hands stops moving.

2. When an athlete jumps from a height on a hard surface, he can hurt his feet. This is because the feet come to rest in a very short time and hence the force exerted on the feet is high. That is why athletes during high jump land on sand or foams. This increases the time in which the body comes to rest. The sad gives way allowing the body to slow down gradually.

Definition of Newton: If force acting on a body of mass 1kg produces an acceleration of 1m/sec^2 in it, the force is called one newton.

Newton's Third Law of Motion: When a body exerts a force on another body, the other body also exerts a force on the first. We say that two bodies interact with each other.

Newton's Third law: "In any interaction between two bodies, the force applied by the first body on the second is equal and opposite to the force applied by the second body on the first." This means force occurs in pairs.

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These two forces have equal magnitude and opposite directions. Such a pair of forces exerted by two bodies on each other is called an action - reaction pair. These action - reaction pair act on two different bodies.

- When a boy carries a heavy load on his head, the load pushes down on his head. The boy's head pushes the load upwards. These forces are equal in magnitude.
- If you hit a wall with your fist, the wall also hits your fist with the same force, which you feel.

Examples of Newton's Third Law

1. Cricket player catching a ball: the player has to exert force on the ball to stop it. By Newton's third law, the ball exerts a force of equal magnitude on the hand. If he pulls his hand back, smaller force will be exerted. If the keeps his hand still, larger force will be exerted.
2. Walking of a person: a person is able to walk because of the Newton's third law of motion. During walking, a person pushes the ground in backward direction and in the reaction; the ground also pushes the person with equal magnitude of force in opposite direction. This enables him to move forwards direction against the push.
3. Recoil of gun: when bullet is fired from a gun, then the bullet also pushes the gun in opposite direction with equal magnitude of force. This results gunman feeling a backward push i.e. recoil force from the gun. Since the gun has greater mass than bullet, acceleration of the gun is much less than the acceleration of the bullet.

4. Rocket Propulsion: the propulsion of the rocket is based on the principle of action and reaction. The rapid burning of fuel produces hot gases which rush out from the nozzle at the rear end at a very high speed. The equal and opposite reaction force moves the rocket upward at a greater speed.
5. When you jump out of the boat onto the shore, you pushes the boat backwards with your feet. By Newton's third law, the boat pushes you in the forward direction. Thus, you move towards the shore and the boat moves away from the shore.

Exercise I

Q1. When a body moves on a surface it will come to rest after some time. The force responsible for bringing the body to rest is called _____force.

Q2. What do we need to do if we want that a ball moving on a surface keeps on moving forever?

Q3. State any three changes a force brings about on a body with one example.

Q4. In which direction the force will act when we apply brakes in our bicycle?

Q5. Prove that you need at least two forces to deform a body.

Exercise 2

Q1. The acceleration of a moving body is 1 ms^{-2}. What is the change in force, if acceleration changes to 2 ms^{-2}

Q2. Due to which property a body resists a change in its direction of motion7

Q3. A car of mass 1000kg is moving with a velocity of 72km/hr. Find its momentum. (20000 kg m/sec)

Q4. Force acts on an object of mass 4kg and changes its velocity from 10 m/sec to 20 m/sec in 5sec. Find the magnitude of force. (8 N)

Numerical Problems

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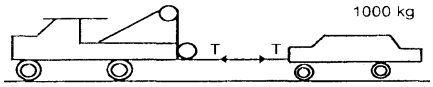
Q1. A truck of mass 5000 kg is moving along a straight road with a speed of 72 km/hr. What is the braking force required to bring it to rest within 100 m? (Negative 10,000 kg m/sec^2)

Q2. A tow truck pulls a car of mass 1000 kg using a rope which can stand a maximum force of 7000 N across its cross—section The truck starts from rest and accelerates to reach a speed of 36 km/hr in 10 seconds Would the rope break? (1000N, not break)



Q3. A steam engine of mass 3 x 10^4 kg accelerates two wagons each of mass 2 X 10^4 kg with 0.2 ms^{-2} Neglecting frictional forces, calculate

a. the force exerted by the engine

b. the force experienced by each wagon

Q4. A truck of mass 5000 kg starting from rest covers a distance of 100 m in 10 s. Calculate the force required to cover this distance. (10000 N or kg ms^{-2})

Q5. Velocity of the body of mass 10 kg is changed from 10 m/s to 20 m/s by applying a constant force, calculate the change in momentum.

Q6. A body of mass 20 kg, starting from rest attains a velocity of 30 km/hr in 10 s by the application of a constant force Calculate the magnitude of force acting on the body.

Q7. A fast moving bus is brought to rest within 15 sec by applying brakes (assume braking force is uniform) If the change in the momentum is 30000 kg ms1, calculate the magnitude of the retarding force.

Q8. A force of 10 N on a body produces an increase in velocity of 30 ms 1 in 10 sec, Calculate the mass of the body.

Exercise 3

Q1. A moving body possesses _____.

Q2. Momentum= _____ x velocity

Q3. The more massive a body, the more is the _____ required to stop it in a given time

Q4. Match the following in the table given alongside.

	Quantity		Units
(i)	Force	(a)	ms^{-2}
(ii)	Momentum	(b)	kg ms^{-2}
(iii)	Velocity	(c)	kg ms^{-1}
(iv)	Acceleration	(d)	ms^{-1}

Q5 A body of mass m is at rest. What is its momentum?

Q6 According to Newton, force can be defined as the rate of change of _____.

Q7. Force of 50 n acts on a body for 1/10 sec. Find the change in the momentum of a body. (5kg m/sec)

Q8. Define 1 Newton of Force.

Q9. According to the Newton's third law, force always exist in _____ pair.

Q10. Why do you fall in the forward direction when a moving bus applies brakes to stop and fall backward when it is accelerated from rest?

Q11 What is the acceleration produced in a moving body of mass 50 kg, when a force of 40 N is applied?

Q12. If a rope pulls vertically upward a furnace of 100 kg starting from rest, and acquires a velocity of 4m/sec in 1 5 second, what should be the tension in the rope?

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Q13. Calculate the momentum of a body of mass 450 g moving with a speed of 120 km/h.

Worksheet

Q1. Define the term 'inertia'. In what form does inertia affect the motion of a body? Describe by giving examples

Q2. Is momentum a vector quantity? Support your answer by giving appropriate examples.

Q3. Mention the force if any that keeps a body moving in a circular motion.

Q4. State the three laws of motion

Q5. Differentiate mass from weight.

Q6. State Newton's second law and express how it reduces to first law.

Q7. What do you understand by the concept of balancing of forces?

Q8. Why do we bend our knees when we Jump from a height?

Q9. When the electric current is switched off, the blades of a fan keep on moving for some time. Give reason

Q10. Can every force produce motion in every object?

Q11. Plot a graph between force applied on a body and the acceleration produced in the given mass, assuming that the magnitude of force is constantly changing.

Q12. When a force acting on a body has equal and opposite reaction,, why does body move?

Q13. Which will produce greater friction?

(a) Wood with wood (b) Glass with glass

Q14. Two blocks made of different metals, identical in shape and size are acted upon by equal forces, which cause them to slide on a horizontal surface The acceleration of the second block is found to be five times the first. What is the ratio of the masses of the second to the first?

Q15. A bomb of mass 6 kg initially at rest explodes into two fragments of masses 4 kg and 2kg respectively. If the greater mass moves with a velocity of 5 m/sec, find the velocity of the 2 kg mass.

Q16. State Newton's first law of motion. Why is it called the 'law of inertia'?

Q17. Why does a ball rolling on a cemented floor eventually come to rest even if no apparent force is applied on it?

Q18. Why is it recommended to wear seat belts while driving?

Q19. Justify the statement; an unbalanced force is required to change the motion of an object'.

Q20. When the card is flicked with the finger, the coin placed over it falls in the tumbler. Why?

Q21. Define inertia.

Q22. Define momentum. Is it a scalar or a vector quantity?

Q23. How is the direction of momentum determined?

Q24. State Newton's second law of motion

Q25. Write the mathematical interpretation of Newton's second law of motion.

Q26. Why is a high jump athlete made to fall on a cushioned bed?

Q27. How does a karate player break a slab of ice with a single blow?

Q28. Why does a fielder pull his hands backwards with the moving ball while taking a catch?