FORCE AND LAWS OF MOTION

Q.1 Define the force .

Force is push or pull acting upon any object or body. Force can be defined as an influence causing a body at rest or moving with constant velocity to undergo acceleration. The SI unit of force is Newton. Example – to open a door, either we push or pull it. A drawer is pulled to open and pushed to close.

Q.2 State four effects, which a force can bring change, giving an example in each case.

(i) Force produces motion in a body.

Example The force exerted by a player, sets a ball in motion.

(ii) Force can stop a moving body.

Example A speeding car is stopped by the force of friction of brakes.

(iii) Force can change the speed or direction of a moving body.

Example (i) A moving car changes its direction when force is applied on its steering wheel.

(iv) Force changes dimensions of a body.

Example Silver flattens to form thin leaves, when hammered.

Q.3 What is meant by the term contact force? Give two examples.

Contact force is defined as the force between any two objects or a surface and an object that are in touch with each other. A contact force can be continuous or momentary. The continuous contact force is also called continuous force whereas the momentary contact force is known as the impulse force. Forces that belong in this category are friction, air resistance, normal force, applied force, tension force, and spring force. Pushing a car or kicking a ball or pushing a desk across a room are some of the everyday examples where contact forces are at work.

Q.4 What is meant by non- contact force? Give two examples.

Non Contact force is a force at a distance. Forces acting on anybody without any physical contact between them. Forces belonging to this category are: Gravitational force, Magnetic force, Electrical force, Nuclear force etc.

There are various examples for non contact forces we visualize in our daily life. Some of them are: (a) Apple falls down from tree gives non contact force viz. gravity. (b) Iron pins at vicinity of a magnet get attracts without any physical contact.

Q.5 State the similarities between contact and non contact forces.

Similarities:

(a) Both contact and non contact forces can be represented by vectors.

(b) Both involve attraction between the objects

Q.6 State the differences between contact and non contact forces.

The differences between contact and non contact forces are -

Contact Forces	Non-contact forces
Force arises due to the conatct beteen two different objects.	Force arises due to attraction or repellsion between two objects there is no contact between the objects.
There is no field associated with a contact force.	There is always a field associated with a non-contact force.
This force takes immediate effect after the applied force.	This force takes more effect after decreasing the distance between two objects.
Example – The force exerted on a book which is placed on a table.	Example – Free fall of feather towaards earth.

Q.7 Name and define absolute units of force in

(a) C.G.S. system

(b) S.I. system.

(a) **Dyne** It is an absolute unit of force in C.G.S system. When a body of mass 1g, moves with an acceleration of 1 cm s^{-2}, the force possessed by it is said to be one dyne.

(b) **Newton (N)** It is an absolute unit of force in S.I. system. When a body of mass 1 kg, moves with an acceleration of 1ms^{-2}, the force possessed by body is said to be one Newton.

Q.8 Prove 1 N = 10^5dynes.

1N = 1kg × 1 ms^{-2}

= 1000 g× 100 cms–2

= 100000 gcms–2

= 10^5dynes.

Q.9.1 Balanced and Unbalanced Forces

Q.1 Differentiate between balanced and unbalanced forces?

Balanced force	Unbalanced force
Here equal forces acts on body in the opposite direction	Here Unequal forces acts on the body the opposite direction
Here net force is zero	The net force is not zero
The body will be at rest	These unbalanced forces make the bo to move
Example-A book kept on the table(**the action force is weight of the book gives out gravity cancels out with the reaction force of the table)**	Example- When the book that is kept the table is pushed to the left side (t **forces gets unbalanced when the bo is given a push to the left side. He there is no force to cancel out in rig side hence it moves).**

Q.2 Explain balanced force and give an example.

Balanced Force A force is said to be balanced if the resultant of all the forces acting on a body is equal to 0. A body under the influence of a balanced force does not change its position of rest or uniform motion and appears as if no force is acting on it. For example: In the game of tug of war, the two teams pull each other in the opposite directions. If the two teams pull the rope with equal force i.e. F1 = F2, then the rope does not move in either direction. Under this condition, the forces acting on a rope are balanced forces

Q.3 What is meant by unbalanced force?

Unbalanced Force A force is said to be unbalanced if the resultant of all the forces acting on a body is not equal to 0. A body under the influence of unbalanced force changes its position of rest and uniform motion.

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.

For example. In the tug of war, if the force applied by a team is greater than that applied by the other team. Then the members of the weaker team will be pulled towards the stronger team. Thus, the unbalanced forces produce motion

9.2 First Law of Motion

Q.1 State Newton's first law of motion: Give any two example from our everyday life .

Newton's first law of motion states that, "An object remains in a state of rest or of uniform motion in a straight line unless compelled to change that state by an applied force". Newton's first law of motion, also known as the law of inertia.

Explanation If any object is in the state of rest, then it will remain in rest until an external force is applied to change its state. Similarly, an object will remain in motion until any external force is applied over it to change its state. 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

• When a bus suddenly starts, the passengers sitting or standing in the bus tend to fall backward. This is due to inertia of rest and can be explained as follows: when the bus suddenly starts, the lower part of the body of the passenger which is in contact with the bus moves along with the bus while the upper part of the body tends to retain its state of rest due to inertia. As a result, the passenger falls backward

• 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 because when the pile is struck with a striker, the coin at the bottom comes in motion 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.

Q.2 What is meant by inertia?

The tendency of an object to resist any change in its state of rest or of uniform motion is called inertia.

Q.3 Define two kinds of inertia. Support your answer with one example each.

Inertia of body is of two kinds:

(i) **Inertia at rest** The tendency of a body to continue in its state of rest, even on the application of external force is called inertia of rest.

Example A rider sitting on a horse back falls backward, if the horse gallops off suddenly. It is because when the horse suddenly sets itself in motion, the rider on account of inertia of rest, tends to continue in the state of rest. Thus, the rider is left behind the horse and hence falls.

(ii) **Inertia of motion** The tendency of a body to continue in its state of uniform motion, even on the application of external force is called inertia of motion.

Example The passengers in a running bus fall in the forward direction, when brakes are applied suddenly. It is because when the bus suddenly comes to rest, the passengers on account of inertia of motion tend to continue to move in forward direction and hence fall forward.

Q. 4 What determines the inertia of a body? Do all bodies have the same inertia?

The mass of body determines its inertia i.e. inertia is directly proportional to the mass of body. Mass of an object is a measure of its inertia. Heavier or more massive objects offer larger inertia.

Q.5 Why do we jerk wet clothes before spreading them on line?

Initially, the water and clothes are in the state of rest. When the clothes are suddenly jerked, the water in them, on account of inertia of rest, tends to continue in its state of rest. Thus, the droplets of water are left behind and fall off the clothes. Removal of water from clothes helps them to dry quickly.

Q.6 Why a neat hole is formed in the glass pane, if a bullet is fired on it from a close range?

When bullet strikes the glass pane, it suddenly sets only that part into motion. However, rest of the glass pane on account of inertia of rest tends to continue in its state of rest. Thus, a neat hole is made in the glass pane as the rest of pane does not get disturbed.

Q.7 Why does a player run for some distance, before taking a long jump?

In running some distance, the player picks up inertia of motion. Thus, during jumping this inertia of motion carries him forward over a longer distance.

Q.8 Why is it necessary to run along with moving bus and in the same direction of bus, while alighting from it?

A person in a moving bus possesses inertia of motion. Thus, if he simply jumps out, his feet suddenly come to rest, but his body continues moving in the direction of bus. Thus, he can fall headlong and seriously injure himself. However, if the person starts running in the direction of the bus, his body will not come to rest. Thus, he will not fall in the forward direction.

Q.9 Explain why some of the leaves may get detached from a tree if we vigorously shake its branch?

When we vigorously shake the branches of a tree , it moves a tree to and fro, but its leaves try to remain at rest and fall down. In this case the inertia of the leaves tend to resist the to and fro motion of tree.

Q.10 Why do you fall in the forward direction when a moving bus brakes to a stop and fall backwards when it accelerates from rest?

In a moving bus, a passenger moves with the bus due to inertia of motion. As the driver applies brakes, the bus comes to rest. But, the passenger tries to maintain to inertia of motion. As a result, a forward force is exerted on him. Similarly, the passenger tends to fall backwards when the bus accelerates from rest. This is because when the bus accelerates, the inertia of rest of the passenger tends to oppose the forward motion of the bus. Hence, the passenger tends to fall backwards when the bus accelerates forward.

Q.11 Why Newton's first law is also called law of inertia?

Every body in the universe opposes the force which tends to change its state of rest or of uniform motion. This property of INERTIA is a direct consequence of FIRST LAW OF MOTION. As heavy bodies due to greater INERTIA requires forces of large magnitude and bodies of small masses require small forces. By the above explanation of INERTIA we conclude that the state of rest or motion does not change by itself unless an external force acts upon it, which is according to the First law of motion.Thus the first law of motion is also called law of inertia.

Q. 12 Why should we wear safety seat belts in a car?

Due to our inertia we may be hurt when the car suddenly starts or stops. Safety belts protect us by showing down the motion in such situations.

Q. 13 What did Galileo conclude on the basis of his experiments on the motion of objects?

A body continues to move with the same velocity if no unbalanced force acts on it.

Q. 14 Show that Newton's first law of motion is a special case of Newton's second law of motion.

The first law of motion can be mathematically stated from the mathematical expression for the second law of motion. F = ma Or F =m (v- u)/t That is, when F = 0, v = u for whatever time, t is taken. This means that the object will continue moving with uniform velocity, u throughout the time, t. If u is zero then v will also be zero. That is, the object will remain at rest.

Q.15 Water sprinkler used for grass lawns begins to rotate as soon as water is supplied. Why?

Water drops have inertia of rest. They do not move with the cloth as it is jerked and come out.

Q.16 Why does a person fall off the back of a stationary horse, if the horse darts off suddenly?

Initially, the person and the horse are in the state of rest. When the horse darts off suddenly, the person on account of inertia of rest, tends to continue in its state of rest. Thus, the person is left behind relative to horse and hence falls in the backward direction

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Q.17 Give two applications of inertia in daily life.

Applications of inertia in daily life are given below

- A carpet is beaten with stick so that dust particles fall down.
- Branches of trees are shaken so that fruits fall down.

Q.18 Why do the doors of a corridor open or shut, when the train starts or stops?

When the train starts suddenly, the sliding doors tend to continue in their state of rest, on account of inertia of rest. Thus, in way doors move backward with respect to the motion of train and hence close. When the train stops suddenly, the doors continue moving forward on account of inertia of motion. Thus, as the doors move in the direction of train, and hence open.

9.3 Newton's second Law of motion

Q.1 State Newton's second Law of motion?

Newton's second Law of motion: This law states that the rate of change of momentum of a body is directly proportional to the applied unbalanced force and the change takes place in the direction of the applied force.This law can be divided into two parts:

(i) The rate of change of momentum of a body is directly proportional to the applied force. The larger force acting on a body, the greater is the change in its momentum. Since the change in momentum is equal to the product of mass and the change in velocity and the mass remaining constant, the rate of change of momentum is directly proportional to the rate of change in velocity. i.e., acceleration. Hence, force(F) is directly proportional to the mass(m) and acceleration. $F \propto ma$ (ii) The change of momentum occurs in the direction of the force: If a body is at rest, a force can set it in motion. If a body is moving with a certain velocity, a force will increase or decrease this velocity accordingly as the force acts in the same or opposite direction.

Q.2 What do you understand by the term momentum ?

It may be defined as the product of mass and velocity of a body and is in fact meant for the measure of the motion of a body. Thus, Momentum = Mass × Velocity Or, $P = m \times v$Momentum of a body has both magnitude and direction and is therefore a vector quantity. Its direction is the same as that of velocity, v. On S.I system, it is measured in Kg.m/sec written as $Kg.msec^{-1}$.

Q.3 Give two examples to illustrate Newton's second law of motion.

Examples to illustrate Newton's second law of motion

• A cricket player lowers his hands while catching a ball. The reason is that by lowering his hands, he increases the time of catching the ball. As a result, the rate of change of momentum decreases and by Newton's second law, the force exerted on his hands is less. So, he is less likely to get hurt. • We get hurt less when we jump on a muddy floor than on a hard floor: When we jump on a muddy floor, the floor is carried in the direction of the jump and the time interval for which force acts is increased. This decreases the rate of change of momentum and hence the force of reaction. Thus, we get less hurt.

Q.4 What is meant by acceleration?

The acceleration of an object is defined as the ratio of change of velocity of the object, and time taken i.e.,Acceleration = change in velocity/time taken. Acceleration is a vector quantity. Acceleration is positive, if the velocity is increasing and is negative if velocity is decreasing.The negative acceleration is called retardation or deceleration

$$a = \frac{v - u}{t}$$

Final velocity is 'v' and initial moving with a velocity 'u' and 't' is time taken.

Q.5 Show that rate of change of momentum is the product of mass and acceleration.

Consider a body of mass 'm' initially moving with a velocity 'u'. Let the body be acted upon by a force 'F' for time 't' (in seconds), such that its final velocity is 'v'. ∴ Initial momentum of body = mu Final momentum of body = mv ∴ Change in momentum in time t= mv− mu ∴ Rate of change of momentum = m(v-u)/t But, a= (v-u)/t, where 'a' is acceleration ∴ Rate of change of momentum = ma According to Newton's second law. Rate of change of momentum ∝force (F) ∴ F ∝ ma or F = Kma, [where K is constant of proportionality] If there be a body of unit mass, having a unit acceleration, such that force possessed by the body is also unit, then: 1= K ×1×1 K = 1. ∴ F = ma.

Q.6 What is meant by net force?

Net force is the sum of all forces acting on an object in a particular direction.

Q.7 What will happen if a body is subject to multiple forces at the same time ?

If a body is subjected to multiple forces at the same time, then the acceleration produced is proportional to the vector sum (that is, the net force) of all the individual forces. $F_1+F_2+.....+F_n = F_{net}= ma$.

The Second Law can also be shown to relate the net force and the momentum p of the body :

Therefore, Newton's Second Law also states that the net force acting on a body is equal to the rate of change of momentum of the body.

Q.8 State two factors which determine momentum of a body?

Momentum is expressed by the equation: p = mv. Therefore, the two factors which determine momentum of a body are

- Momentum is directly proportional to the mass of body.
- Momentum is directly proportional to the velocity of body.

Q.9 Athletes' in pole jump events fall on cushioned surface and not on floor. Why?

The change in momentum occurs in a long duration of time which reduces the force acting on athlete and he does not hurt.

Q.10 Why does the fielder pull his arms back while trying to stop or catch a cricket ball?

The fielder pulls his hands backwards after holding the ball to decrease the rate of change of momentum by increasing the time. By doing this, less force is exerted on his hands (therefore Force is directly proportional to the rate of change of momentum).

Q.11 A passenger in a moving train tosses a coin which falls behind him. From this incident, what you can predict about the motion of train?

If the coin falls behind the passenger that means the train is accelerated. When the coin is tossed it has same velocity as that of train but during the time it is in air its velocity becomes less than that of train (because the train is accelerated), so it falls behind the passenger.

Q.12 While riding on the bicycle, if we stop peddling, why does the bicycle begin to slow down?

The bicycle begin to slow down because force of friction which is acting in opposite direction to that of motion.

Q.13 Why can a small mass such as a bullet kill a person when fired from a gun?

A small mass such as a bullet kill a person when fired from a gun because even if the mass of the bullet is small, it moves out of the gun with a very high velocity, due to which the momentum produced is high (p = mv). This high momentum of the bullet kills a person.

Q.14 What is impulse?

Impulse is defined as change in momentum.

Impulse : -

From second law of motion $F = ma$ or $F = m \nabla v/t$

$F.t = m\nabla v$

Force.Time is known as impulse where t is the time for which average force acts, is change in linear momentum of the body.

Q.15 What is meant by friction?

Friction is the opposing force that comes into play when one body is actually moving over the surface of another body or one body is trying to move over the surface of the other.

9.4 Newton's third Law of motion

Q.1 State and explain Newton's third Law of motion.

Newton's Third Law is sometimes called the Law of Reciprocal Actions or the **Action-Reaction Law**

Whenever one body exerts force upon a second body, the second body exerts an equal and opposite force upon the first body.

This is often stated as: "For every action there is an equal and opposite reaction."

$F_{ACTION} = -F_{REACTION}$

Force exerted by one body is called ACTION and the force exerted by the second body is called REACTION.

EXAMPLES • Motion of rocket Fuel burns rapidly, exerts force in downward direction and rocket moves upward as a reaction. • **Book lying on a table** weight of the book on the surface is action and the force exerted by the surface (R) is the reaction. **R = -W**

Q.2 If action is always equal to the reaction, explain how a horse can pull a cart.

A horse pushes the ground with foot in the backward direction. According to Newton's third law of motion, a reaction force is exerted by the Earth on the horse in the forward direction. Hence, the cart moves forward.

Q.3 Does Newton's third law apply to a system where bodies do not actually touch each other?

Yes, whenever the bodies are in actual contact or even if there is an interaction between the bodies (e.g., attraction or repulsion between two magnets charges, etc.) Newton's third law is applicable

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Q.4 Explain, why is it difficult for a fireman to hold a hose, which ejects large amounts of water at a high velocity?

It is difficult for a fireman to hold a hose, which ejects large amounts of water at a high velocity due to the backward force applied by ejected water. When a fireman holds a hose, which is ejecting large amounts of water at a high velocity, then a reaction force is exerted on him by the ejecting water in the backward direction. This is because of Newton's third law of motion. As a result of the backward force, the stability of the fireman decreases. Hence, it is difficult for him to remain stable while holding the hose.

Q.5 Why a boatman pushes the bank backward with a long bamboo pole, on launching his boat in water?

When the boatman pushes the bank with pole in the backward direction, the bank reacts back according to Newton's third law and pushes the pole in the opposite direction. As the pole is in the hands of boatman, who is standing in the boat, therefore, whole system moves in the opposite direction i.e. in the forward direction.

Q.6 Describe our walking in terms of Newton's third law of motion.

When we walk on the ground or road, our foot pushes the ground backward(action) and the ground pushes our foot forward (reaction). Thus, the forward reaction exerted by the ground on our foot makes us walk forward.

Q.7 Two identical bullets are fired one by one by one by a light rifle and another by a heavy rifle with the same force, which rifle will hurt the shoulder more and why?

As both the bullets are identical and are fired with the same force. So, according to Newtons's third law of motion, same force will be applied on both the rifles. With the application of same force, the light rifle will move more quickly in the backward direction, so it will hurt more to the shoulder.

9.5 Law of Conservation of Momentum

Q.1 State the Law of Conservation of Momentum. Deduce this from Newton's second law of motion.

Law of conservation of momentum: When two or more bodies interact with one another, the vector sum of their linear momenta remains constant (i.e., conserved), and is not affected due to their mutual action and reaction. The only condition is that no external unbalanced forces should be acting on the system of bodies. For example in a collision occurring between object 1

and object 2 in an isolated system, the total momentum of the two objects before the collision is equal to the total momentum of the two objects after the collision. That is, the momentum lost by object 1 is equal to the momentum gained by object 2.

Derivation of Law of Conservation of Momentum from Newton's Second Law

Suppose p_1 and p_2 represent the sum of momentum of a group of objects before and after the collision respectively. Let 't' be the time elapsed during collision. Then, according to Newton's second law External force= Rate of change of momentum or F= $(p_2-p_1)/ t$ If there is no external force, F=0 and $(p_2-p_1)/t =0$ or, $p_{1=} p_2$ Therefore, in the absence of an external force, the total momentum of a group of objects remains unchanged or conserved during collision. This is the Law of Conservation of Momentum.

Q.2 How will you prove the law of conservation of momentum by using the example of an ideal collision?

We can prove the law of conservation of momentum by considering an ideal collision experiment between two bodies. Suppose two objects (two balls A and B, say) of masses m_A and m_B are travelling in the same direction along a straight line at different velocities u_A and u_B, respectively. And there are not other external unbalanced forces acting on them. Let $u_A > u_B$ and the two balls collide with each other. During collision which lasts for a time 't', the ball A exerts a force F_{AB} on ball B and the ball B exerts force F_{BA} on ball A. Suppose V_A and V_B are the velocities of the two balls A and B after the collision, respectively. We know the momenta of ball A before the collision = m_Au_A and the momenta of ball A after the collision = m_Av_A The rate of change of its momentum (or F_{AB}, action) during the collision will be Similarly, the rate of change of momentum of ball B (=F_{BA} or reaction) during the collision will be According to the third law of motion, the force F_{AB} exerted by ball A on ball B (action) and the force F_{BA} exerted by the ball B on ball A (reaction) must be equal and opposite to each other. Therefore, $F_{AB} = -F_{BA}$ or This gives,$m_Au_A + m_Bu_B = m_Av_A + m_Bv_B$ Since $(m_Au_A + m_Bu_B)$ is the total momentum of the two balls A and B before the collision and $(m_Av_A + m_Bv_B)$ is their total momentum after the collision, form equation we observe that the total momentum of the two balls remains unchanged or conserved provided no other external force acts. As a result of this ideal collision experiment, we say that the sum of momenta of the two objects before collision is equal to the sum of momenta after the collision provided there is no external unbalanced force acting on them. This is known as the **law of conservation of momentum**.

Q.3 Why does a gun recoil?

When a gun is fired, it exerts a forward force on the bullet. The bullet exerts an equal and opposite reaction force on the gun. This results in the recoil of the gun since the gun has a much greater mass than the bullet, the acceleration of the gun is much less than the acceleration of the bullet

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Q.4 Why does a swimmer push water backward with his hands, in order to swim in forward direction?

When the swimmer pushes the water backward, then according to Newton's third law the water reacts back and pushes the swimmer in forward direction

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Q.5 How do the rockets operate in space?

When the fuel burns in the ignition chamber of a rocket, the hot gases pass out from its exhaust with a certain momentum in backward direction. Thus, in order to conserve momentum the rocket moves with the same momentum in forward direction.

Q.6 Why does an air filled balloon rise up slightly when punctured from below?

When the air at the point of puncture moves out with a certain momentum in the downward direction, in order to conserve momentum the balloon moves with the same momentum in opposite direction. Thus, balloon rise up slightly, before falling down.

Q.7 Define the term mass of body? Will mass of a body change with the change in the position or surroundings?

The amount of matter contained in a body is called mass. SI unit of mass is kilogram (kg) and CGS unit is gram (g). Mass of body does not change, with the change in the position or surroundings.

Q.8 Why mass is sometimes called coefficient of linear inertia?

It is easier to pull a lighter body than a heavier body. Therefore, more the mass more will be the inertia. That is why mass is sometimes termed a coefficient of linear inertia.

Q.9 What is the net momentum of gun and bullet system before firing and after firing?

The net momentum of gun and bullet system before firing is zero, as velocities of both (gun and bullet) are zero.The momentum of gun and bullet system after firing is equal to initial momentum, i.e., zero because no external force is acting

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Q.10 What do you mean by a resultant force?

When two or more forces act on a body simultaneously, then the single force which produces the same effect as produced by all the forces acting together is known as the resultant force.

VALUE BASED QUESTION:

Q.1 William was having a gun-shoot session in a training camp. As soon as he shot a bullet, he fell backwards. Sanat started making fun of him. William stood up and explained the cause of this effect and told him not to laugh without understanding the scientific cause behind it.

(i) Which law can explain the process of recoil of gun?

(ii) Why does a gun recoil back, when fired?

(i) He fell down due to recoil force of gun. Newton's third law of motion explains the process of recoil of gun. When a gun is fired, it exerts a forward force on the bullet. The bullet in turn exerts an equal and opposite force on the gun. This results in the recoil of the gun.

(ii) William is logical and scientific, while Sanat needs to work on his basic ethics and listen to the facts behind this phenomenon.

Q.2 Ramu and Sharat were playing 'catch the ball' in a park. Ramu was able to catch the ball comfortably without hurting himself; while Sharat was hurt every time he caught a ball. Finally, Sharat asked Ramu how he could catch the ball with ease. Ramu explained the method to Sharat. Sharat thanked him.

(i) Why was Ramu not hurt while catching the ball?

(ii) Compare and contrast the values of Ramu and Sharat.

(i) Ramu would lower his hands while catching the ball. This increased time of momentum change and ball exerted less force on hands of Ramu.

(ii) Sharat is inquisitive, accommodating and a keen observer. Ramu is scientifically tempered, helpful, logical and has applicative mind.

Numerical Problems

Q.1 A car of mass 200 kg moving at 36 km/h is brought to rest after it covered a distance of 10 m. Find the retarding force acting on the car? Mass of the car (m) = 200 kg Initial speed (u) = 36 km/h = 10 m/s Final velocity (v) = 0 Distance covered (S) = 10 m v2 - u2 = 2aS 0 - 100 = 2 x a x 10 - 100 = 20 a

$a = - 100/20 = -5\ m/s^2$

F = ma = 200 x -5 = -1000 N Retarding force = 1000 N

Q.2 What will be the momentum of a stone having mass of 20 kg when it is thrown with a velocity of 4m/s? Given, Mass (m) = 20kg Velocity (v) = 4m/s Momentum (p) =? Momentum (p) = Mass (m) x Velocity (v) Therefore, p = 20kg x 4 m/s = 80 kg m/s Thus, the momentum of the stone = 80 kg m/s.

Q.3 The mass of a goods lorry is 5500 kg and the mass of goods loaded on it is 10000 kg. If the lorry is moving with a velocity of 2m/s what will be its momentum?

Given, Velocity (v) = 2m/s Mass of lorry = 5500 kg, Mass of goods on the lorry = 10000 kgTherefore, total mass (m) of the lorry = 5500 kg + 10000 kg = 15500 kg Momentum (p) =? Momentum (p) = Mass (m) x Velocity (v) Therefore, p = 15500 kg x 2 m/s = 31000 kg m/s Thus, momentum of the lorry = 31000 kg m/s.

Q.4 A vehicle is running with a velocity of 5m/s. If the momentum of the vehicle is 5000 kg m/s. What is its mass?

Given, Momentum (p) = 5000 kg m/s Velocity (v) = 5m/s Mass (m) =? Momentum (p) = Mass (m) x Velocity (v) Therefore, 5000 kg m/s = m × 5m/s m=5000kgm/s/ 5m/s= 1000 kg Thus, mass of the vehicle = 1000 kg

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Q.5 A bird is flying with a velocity of 3 m/s. If the momentum of the bird is 4.20 kg m/s. What is its mass?

Given, Momentum (p) = 4.20 kg m/s Velocity (v) = 3 m/s Mass (M) =? We know that, Momentum (p) = Mass (M) x Velocity (v) Therefore, 4.20 kg m/s = M × 3 m/s M= 4.20/3=1.40 kg or 1kg 400g Thus, mass of the bird = 1 kg 400 g

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Q.6 If the momentum of a flying vulture is 30 kg m/s and its mass is 5 kg. Calculate its velocity?

Given, Momentum (m) = 30kg m/s Mass (m) = 5kg Velocity (v) =? We know that, Momentum (p) = Mass (m) x Velocity (v) ⇒ 30 kg m/s = 5kg × v v=30/3= 10m/s Thus, velocity of the vulture = 10m/s

Q.7 Calculate the velocity of a missile having mass of 200 kg, if it attains a momentum of 5000 kg m/s when fired from a rocket gun?

Given, Momentum (m) = 5000kg m/s Mass (m) = 200kg Velocity (v) =? We know that, Momentum (p) = Mass (m) x Velocity (v) ⇒ 5000 kg m/s = 200kg × v v= 5000/200= 25m/s Thus, velocity of the missile = 25 m/s

Q.8 If the mass of a moving object is 60 kg, what force will be required to speed up the object at a rate of $3ms^{-2}$?

According to the question, Acceleration (a) = $3ms^{-2}$ and Mass (m) = 60 kg, therefore, Force (F) =? We know that, F = m x a = 60 kg x $3m/s^2$ = 180 kg m/s^2 Therefore, required Force = 180 m/s^2 or 180 N

Q.9 To accelerate a vehicle to $5m/s^2$ what force will be needed if the mass of the vehicle is equal to 100 kg?

According to the question, Acceleration (a) = $5m/s^2$ and Mass (m) = 100 kg, therefore, Force (F) =? We know that, F = m x a = 100 kg x $5m/s^2$ = 500 kg m/s^2 Therefore, required Force = 500 m/s^2 or 500 N

Q.10 What will be the change in acceleration of a sliding block, if it's mass is doubled while a constant force is acting on it?

Force exerted on the block (F) = ma Let force acting on the object when the mass is doubled be equal to F_1 i.e., Mass (m_1) = 2 m Acceleration produced = a_1

F_1 = 2m x a_1 Given F = F_1 a_1 = a/2 i.e., acceleration is reduced to half. ma = 2 ma_1 a = 2 a_1

Q.11 A bus starts from the stop and take 50 second to get the speed of 10m/s. If the mass of the bus along with passengers is 5500 kg, calculate the force applied by the engine of bus to push the bus at the speed of 10m/s.

According to the question: Initial velocity (u) = 0, final velocity (v) = 10m/s, time (t) = 50 second, Mass (m) = 5500 kg, Therefore, force (F)=? By applying, Since, a= v-u/t Therefore, F=m(v-u)/t F= 5500(10m/s-0m/s)/ 50s F=5500(10m/s)/50s F= 5500x $1/5ms^{-2}$ F=1100 $kgms^{-2}$ or, 1100 N Thus, required force = 1100 N

Q.12 A car having mass of 1500 kg achieve the velocity of 5 m/s in 10 second. Calculate the required force to attain required speed by car?

Given values are- Initial velocity (u) = 0, final velocity (v) = 5m/s, time (t) = 10 second, Mass (m) = 1500 kg, Therefore, force (F)=? Force= m(v-u)/t Since, a= v-u/t Therefore, F= 1500 kg (5m/s-0)/10s = 1500 kg x 1/2 ms^{-2} ⇒ 750 $kgms^{-2}$ or 750 N Thus, required force = 750 N

Q.13 An object gets 20 second to increase the speed from 10m/s to 50m/s. If the mass of the object is 1000 kg, what force will be required to do so?

Initial velocity (u) = 10m/s, final velocity (v) = 50m/s, time (t) = 20 second, Mass (m) = 1000 kg, force (F)=? Force(F) = m(v-u)/t

$$F = \frac{1000kg(50m/s - 10m/s)}{20\ \text{sec}}$$

$$F = \frac{1000kg \times 40m/\ \text{sec}}{20\ \text{sec}}$$

2000 kg m/sec^2 or 2000 N

Q.14 A car initially at rest picks up a velocity of 72 kmh^{-1} is 20 s. If the mass of car is 1000 kg, calculate

(i) Force developed by its engine?

(ii) Distance covered by the car?

u = 0; v= 72 kmh–1= 20 ms–1; t = 20 s; m= 1000 kg, F = ?; S = ? By applying :v = u+ at 20 = 0 + a× 20 ∴ a = 1 ms–2 (i) Force developed by engine (F) = ma = 1000 kg× 1 ms–2=1000 N (ii) By applying : v2–u2= 2aS ∴ (20)^2– (0)^2= 2 × 1 s ∴ S = 400/20 = 20 m

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Q.15 In how much time an object having mass of 100kg will speed up from 10m/s to 30m/s, if 500N force will be applied over it?

According to the question:

Initial velocity (u) = 10m/s, final velocity (v) = 30m/s, Mass (m) = 100 kg, Force (F) = 500N

Therefore, time (t) = ?

F = m(v-u)/t

Since, a = v-u/t

$$\text{Therefore, } 500N = \frac{100kg \times (30-10)ms^{-1}}{t}$$

500N =100 kg x 20ms-^{1}/t

500Nx t= 2000 kg m/s

t= 2000 kgms^{-1}/500 kg m/s2 = 4s

Thus, required time = 4 second

Q.16 The acceleration of two objects are 5m/s^2 and 20m/s^2. If mass of both the object would be combined and a force of 50N would be applied on them, what will be their acceleration?

In the order to calculate the acceleration of both the objects after combining their mass, first of all their mass will be calculated. **Ist object** Given, Acceleration (a) = 20m/s^2 Let the mass of one body = m_1 And a force of 50N will be applied over it. We know that Force (F) = Mass (m) x Acceleration (a)⇒ 50N = m_1 × 5ms^{-2} m_1=50N/5ms-2 = 10kg **2nd Object**

Given, Acceleration (a) = 20m/s^2 Let the mass of one body = m_2 And a force of 50N will be applied over it. We know that Force (F) = Mass (m) x Acceleration (a) ⇒ 50N = m_2 × 20 ms^{-2} m_2 = 50N/20 ms^{-2} = 2.5kg Now, their total mass = m_1 + m_2 = 10 kg + 2.5 kg = 12.5 kg In this condition: Mass (m) = 12.5 kg, Force (F) = 50N, therefore, Acceleration (a) =? We know that, F = m x a a=50N/12.5 kg= 4ms^{-2} Therefore, 50N = 12.5kg × a Thus, Acceleration = 4 ms^{-2}

Q.17 A certain force exerted for 1.2 seconds raises the speed of an object from 1.8 m/s to 4.2 m/s. Later the same force is applied for 2 seconds. How much does the velocity change in 2 seconds?

Initial velocity (u) = 1.8 m/s. Final velocity (v) = 4.2 m/s Time (t) = 1.2 seconds First calculate acceleration a = (v-u)/t = (4.2 - 1.8)/1.2= 2 m/s^2 As the same force acts for the next two seconds the acceleration produced will be the same. The final velocity in the first case will now become the initial velocity. We have to calculate the final velocity at end of 2 seconds. Acceleration (a) = 2 m/s^2 Initial velocity (u) = 4.2 m/s, t = 2 s Final velocity (v) = ? [First equation of motion] v = u + at [First equation of motion] = 4.2 + 2 x2 = 4.2 + 4 = 8.2 m/sChange in velocity in two seconds = 8.2 - 4.2 = 4 m/s

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Q.18 A train is travelling from city A to city B with the speed of 70 mph and while travelling back from city B to city A it travels with the speed of 85 mph. Find the average speed of the train for the whole trip?

As we know that the train is travelling between city A and B, so, the distance travelled by it is two times that of the distance between city A and B. Now, consider that D = distance between city A and B , t_1 = Time taken by train to travel from city A to B = D/70, t_2 = Time taken by train to travel from city B to A = D/85, Similarly, S_1= Speed of the train from city A to B = 70 mph S_2 = Speed of the train from city B to A = 85 mph So, the average speed of the round trip is S_{avg} = (Total Distance Travelled)/Time Taken Savg = 2D/ (D/70+D/85)

$$\frac{2D}{(17D+14D)/1190} \Rightarrow \frac{2D\times1190}{31D} \Rightarrow \frac{238}{31}$$

S_{avg} = 76.77mph. So, the average speed of the train for the round trip is 76.77 mph.

Q.19 A 4kg object is moving across a frictionless surface with a constant velocity of 2 m/s. Determine the force necessary to maintain this state of motion?

Zero Applying Newton's First Law of Motion, this object will continue its state of uniform speed in a straight line until a net (unbalanced) force acts upon it. Applying Newton's Second Law of Motion, since acceleration is zero, the net force acting on the object is zero. An additional force applied to the object will cause acceleration.

Q.20 An object sits on a frictionless surface. There is a 16 N force being applied to an object and its acceleration is at 2 m/s^2. What is its mass?

Applying Newton's Second Law of Motion, F = ma 16 N = m(2 m/s^2) m = 8 kg

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Q.21 Two bodies P and Q are of the same mass, but are moving with velocities of v m/s and 5v m/s respectively.

Compare their

(i) inertia

(ii) momentum.

(i) The inertia of a body is directly proportional to its mass. As the mass of bodies P and Q is same, Therefore, ratio of inertia of P and Q = 1 : 1.

(ii) Momentum of body P = mv Momentum of body Q = m × 5v= 5mv.∴ Ratio of momentum of P and Q = mv: 5 mv = 1 : 5

Q.22 A bullet of mass 30 g and moving with velocity x, hits a wooden target with a force of 187.5 N. If the bullet penetrates 80 cm in the target, what is the magnitude of x?

m = 30 g = 0.03 kg; v = 0; F = –187.5 N; S = 80 cm = 0.80 m; a = ?; u= xBy applying the formula- F = ma Therefore, a=F/m = –187.5 N/0.03 kg = – 6250 ms–2 By applying the formula, $v^2 – u^2 = 2aS$ $(0)^2–(x)^2 = 2 × –6250 × 0.8–x^2 = –10000$ x = 100 $ms^{–1}$

Q.23 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 ms^{-2} ?

Mass, m = 1500 kg Acceleration, a = - 1.7 m/s^2 Therefore Force, F = ma = 1500 × (- 1.7) = - 2550 N (against the direction of motion)

Q.24 What the acceleration a vehicle having 2000 kg of mass will get after applying a force of 10000N?

According to question: Mass (m) = 2000 kg, Force (F) = 10000N, Acceleration (a) =?We know that, Force = Mass x Acceleration or F = m x a Therefore, 10000N=2000 kg x a Therefore, a = 10000N/2000kg a = 5m/s2 Thus, acceleration of the vehicle = 5 ms^2

Q.25 A bullet of 5 gm is fired from a pistol of 1.5 kg. If the recoil velocity of pistol is 1.5 m/s, find the velocity of bullet?

Here we have, Mass of bullet, m_1 = 5 gm = 5/1000 kg = 0.005 kg Mass of pistol, m_2 = 1.5 kg Recoil velocity of pistol v_2 = 1.5 m/s Velocity of bullet v_1 =? Since, before firing the bullet and pistol are in rest, thus Initial velocity of bullet, u_1 =0 And initial recoil velocity of pistol, u_2 =0 We know that, $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$ =0.005 kg x 0 + 1.5 kg x0 = 0.005kg x v_1 + 2.25 kgm/s 0.005kg x v_1 = -2.25 $kg_{m/s}$ v_1= - 2.25kgm/s/ 0.005 kg= -450m/s Thus, velocity of bullet = 450 m/s, here negative sign with velocity of pistol shows that, bullet moves in the opposite direction of pistol.