Force and Laws of Motion

Periodic Test

Q.1. Give two examples of force that compresses.

Answer:

● When we apply pressure on a spring, it gets compressed.

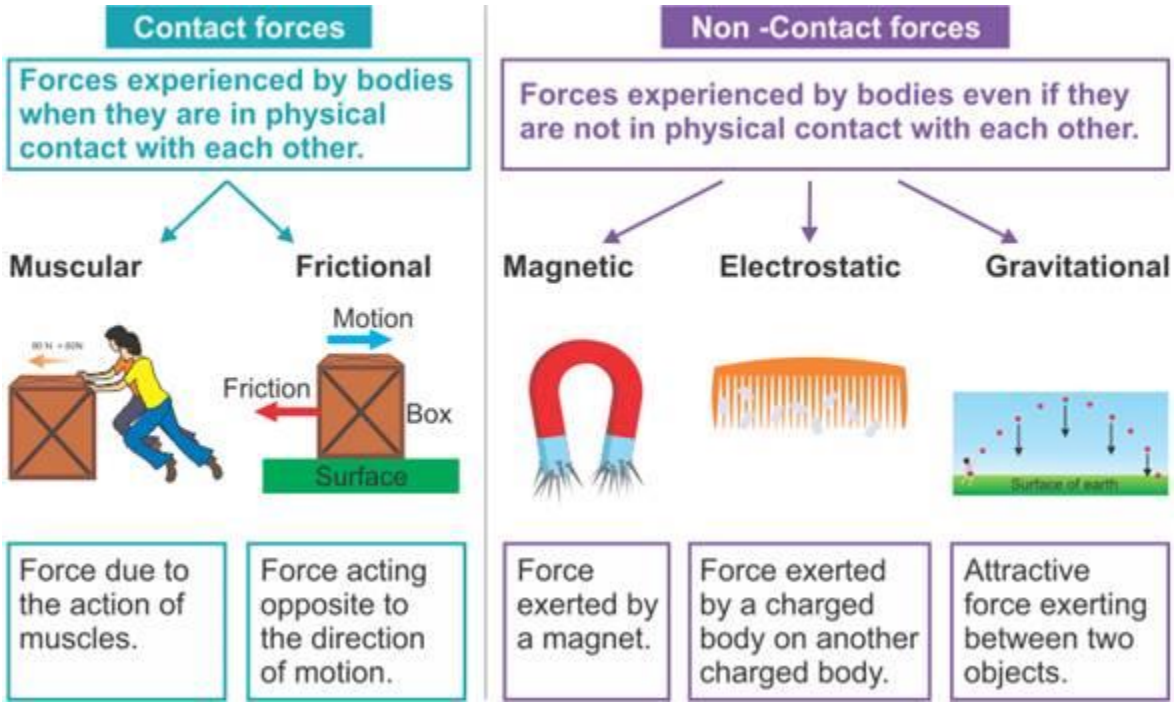
● When we squeeze a rubber ball by allying force with our hands, it get compressed.

Q.2. You are hurt when you kick a stone. Why?

Answer: According to Newton's third law, to every action there is an equal and opposite reaction. So, when we kick a stone with much force, an equal and opposite reaction from the stone is applied on our legs which hurt our legs.

Q.3. Define force.

Answer: Force is any interaction that will change the motion of an object when unopposed. A force can cause an object with mass to change its velocity which includes to begin moving from a state of rest, i.e., to accelerate. Force is a vector quantity as it has both magnitude and direction. Mathematically, Force = mass acceleration. Its S.I. unit is Newton.



Q.4. Define the unit Newton.

Answer: One Newton is the force required to accelerate one kilogram of mass at the rate of one meter per Second Square in the direction of the applied force.

Q.5. Name the cgs unit of force.

Answer: Dyne is the CGS unit of force One dyne is equal to the force needed to accelerate one gram of mass at the rate of one centimeter per second square.

Q.6. Give Reasons for the Following:

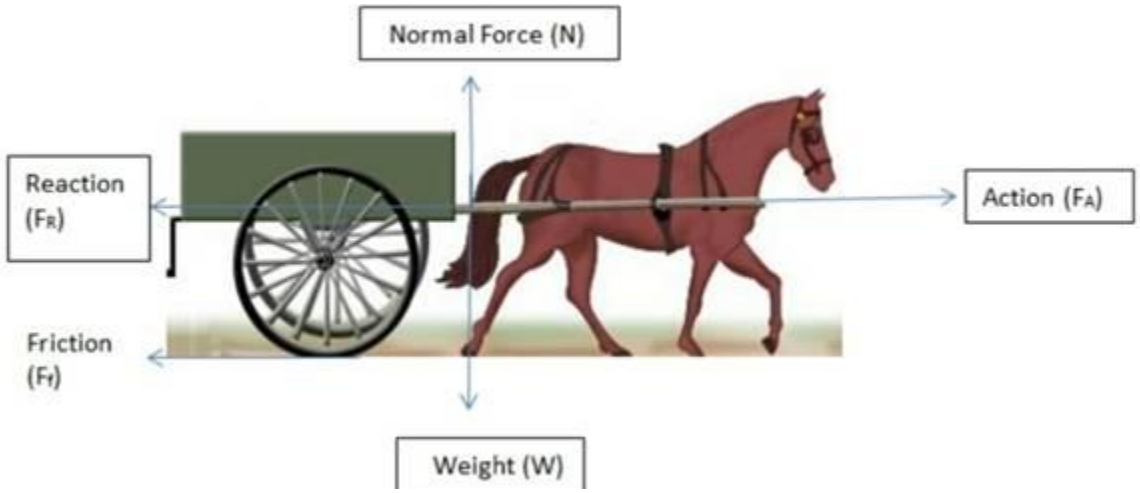
When a carpet is beaten with a stick, dust comes out, why?

Answer: According to Newton's law, an object which is at rest or in motion will continue its state of rest or motion unless and until an external force is applied on it. This property is known as inertia. Dust particles are at rest with respect to the carpet. When the carpet is beaten, the dust due to inertia tends to remain at rest while the carpet moves due to external force applied. So, the dust comes out of the carpet.

Q.7. Give Reasons for the Following:

If action is always equal to reaction explain, why a cart pulled by a horse can be moved?

Answer: According to Newton's third law, to every action there is equal and opposite reaction. In the horse and cart system, the horse is applying force on the cart and instantaneously the cart exerts an equal and opposite force on the horse. But these two forces are acting on two different objects and not on the same object and therefore the force will not get cancelled. Thus, the horse is able to pull the cart.



Q.8. Give Reasons for the Following:

Why is it difficult to balance our body when we accidentally step on the peel of banana?

Answer: We are able to walk due to force of friction. Friction is a contact force and arises when two objects are in direct contact with each other. While walking our feet exerts force on the ground pushing it backwards and the ground exerts equal and opposite reaction to our feet helping us to move forward. When we step on banana peel, the friction force between the feet and the peel decreases and we are not able to move forward and slip.

Q.9. Give Reasons for the Following:

Why some of the leaves may fall from a tree, if we vigorously shake its branch?

Answer: The leaves are at rest with respect to the tree. According to law of inertia, it has a tendency to remain at rest and is resistant to change its state. When we apply external force on the branches, the branches are in motion but the leaves remain at rest due to which it falls off.

Q.10. Give Reasons for the Following:

Why is it advised to tie the luggage with a rope on the roof of buses?

Answer: Luggage is in contact with the roof of the bus. When the bus is moving the luggage is also in the state of motion and had a tendency to remain in motion due to law of inertia. When the driver apply the brakes, the bus stops suddenly but the luggage is in motion and thus fall from the roof. It is therefore advised to tie the luggage.

Q.11. Balanced and unbalanced forces.

Answer:

Balanced forces	Unbalanced forces
1. Balanced forces acts on an object in opposite directions and are equal in strength. They do not cause a change in the speed of a moving object.	1. When two unbalanced forces are exerted in opposite directions, their combined force is equal to the difference between the two forces.
2. There is no net motion of the object on which the force is being applied.	2. There is net motion in the direction of the applied force which has greater magnitude.
3. For example: An object at rest.	3. For example: In tug of wire, unbalanced force is applied by the teams.

Q.12. Mass and inertia

Answer:

Mass	Inertia
1. Mass is the quantity of matter in a body regardless of its volume or of any forces acting on it.	1. Inertia is a tendency of an object to continue its state of rest or motion.
2. Mass is an absolute quantity and is a measure of inertia. It is the resistance of an object to change its state of motion.	2. Inertia depends on mass. Larger the mass, larger the inertia.

Q.13. Motion and force of friction.

Answer:

Motion	Friction
1. Motion is a change in position or displacement of an object with respect to time. Motion is mathematically described in terms of displacement, distance, velocity, acceleration, time, and speed.	1. Friction is the force resisting the relative motion of solid surfaces, fluid layers, and material elements sliding against each other.
2. Contact between the objects is not required for motion of the object.	2. Contact between the objects is required so that friction can come into existence.
3. For example: pushing a block leads to its motion in the direction of applied force, throwing a ball etc.	3. For example: walking on the ground, riding a bicycle etc.

Q.14. Force and momentum

Answer:

Force	Momentum
1. Force is any interaction that will change the motion of an object when unopposed. A force can cause an object with mass to change its velocity which includes to begin moving from a state of rest, i.e., to accelerate.	1. Momentum is the property or tendency of a moving object to continue moving.
2. Mathematically, Force = mass × acceleration	2. Momentum = mass × velocity.
3. S.I. unit of force is Newton.	3. S.I. unit of momentum is kg m/s.

Q.15. First and second law of motion.

Answer:

First Law of Motion	Second law of motion
1. Newton's first law states that an object at rest will stay at rest and an object in motion will stay in motion with the same speed and direction unless and until an external force is applied on the object.	1. Newton's second law states that the rate of change of momentum of a body is directly proportional to the force applied, and this change in momentum takes place in the direction of the applied force.
2. This law is also known as law of inertia.	2. This law is also known as law of force and acceleration.
3. For example: when brakes are applied we tend to move forward, car takes sharp turn then we are thrown outwards.	3. For example: when we push a small stone and a huge rock then the stone will be accelerated because it has less mass.

Q. 16. Show that the rate of change of momentum is equal to product of mass and acceleration.

Answer: Let an object of mass 'm' is moving along a straight line with initial velocity 'u'. A constant force 'F' is applied in time 't' to accelerate it and its final velocity becomes 'v'.

Initial momentum, $p_1 = mu$
Final momentum, $p_2 = mv$
Change in momentum $\propto p_2 - p_1$
$\propto mv - mu$

$\propto m(v - u)$

The rate of change of momentum = $\frac{m(v-u)}{t}$

Rate of change of momentum = force applied

Force $\propto \frac{m(v-u)}{t}$

Force = k $\frac{m(v-u)}{t}$ where k = proportionality constant

Force = kma where a = acceleration = $\frac{m(v-u)}{t}$

Q.17. State the law of conservation of momentum. Derive it by using Newton's third law of motion.

Answer: Law of conservation of momentum states that total momentum of the system remains conserved in the absence of external force.

Proof: Consider two bodies of mass m_1 and m_2 moving with initial velocity u_1 and $u_2$respectively. The two bodies collide with each other for a time interval 't'. The velocity after collision be v_1 & v_2 respectively. Let F_{12} be the force applied by m_1 on m_2 and F_{21} be the force applied by m_2 on m_1.

Momentum of mass m_1 before collision = $m_1 u_1$

Momentum of mass m_2 before collision = $m_2 u_2$

Momentum of mass m_1 after collision = $m_1 v_1$

Momentum of mass m_2 after collision = $m_2 v_2$

Impulse = force × time = change in momentum

For mass m_1 :

$F_{12} t = m_1 v_1 - m_1 u_1$ …….(1)

For mass m_2:

$F_{21}t = m_2 v_2 – m_2 u_2$ …….(2)

Adding equation (1) & (2)

$F_{12} t + F_{21}t = (m_1 v_1 - m_1 u_1) + (m_2 v_2 – m_2 u_2)$

$(F_{12} + F_{21}) t = (m_1 v_1 + m_2 v_2) - (m_1 u_1 + m_2 u_2)$

According to Newton's third law:

$F_{12} = - F_{21}$

$F_{12} + F_{21} = 0$

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

Final momentum = Initial momentum

Hence momentum is conserved.

Q. 18. When a force of 40 N is applied on a body it moves with an acceleration of 5 m s^{-2}. Calculate the mass of the body.

Answer: Force = 40 N

Acceleration = 5 m s^{-2}

force = mass $\times$ acceleration

mass = $\frac{\text{force}}{\text{acceleration}} = \frac{40\ \text{N}}{5\ \text{m s}-2} = 8$ kg

Q.19. It is required to increase the velocity of a scooter of mass 80 kg from 5 to 25 m s^{-1} in 2 second. Calculate the force required.

Answer: Mass = 80 kg

Initial velocity, u = 5 m s^{-1}

final velocity, v = 25 m s^{-1}

Time, t = 2 sec

Rate of change of momentum = force applied

Force $= \frac{m(v-u)}{t} = \frac{80(25-5)}{2} = \frac{80\times20}{2} = \frac{1600}{2} = 800$N

Q.20. 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 5 times that of the first. What is the ratio of the mass of the second to first?

Answer: Let the mass of first block = m_1

acceleration of block of mass m_1 = a

Let the mass of second block = m_2

acceleration of block of mass m_2 = 5a

Force = mass × acceleration

Since forces are equal,

m_1 a = $m_2$5a

$\frac{m1}{m2} = \frac{5a}{a} = 5$

$\frac{m2}{m1} = \frac{1}{5}$

Q.21. An object undergoes an acceleration of 8 m s^{-2} starting from rest. Find the distance travelled in 1 second.

Answer: Acceleration = 8 m s^{-2}

Time = 1 sec

Distance travelled, s =?

Initial velocity, u = 0

Using the equation, s = ut + $\frac{1}{2}$ at^2

$s = 0 \times 1 + \frac{1}{2} \times 8 \times 1^2 = 4\ meter$

Q. 22. A body of mass 500 g is at rest on a frictionless surface. Calculate the distance travelled by it in 10 second when acted upon by a force of 10^{-2} N.

Answer: Force = 10^{-2} N = 0.01 N initial velocity, u = 0

mass, m = 500 g = 0.5 kg distance travelled, s =?time, t = 10 secForce = mass × acceleration

acceleration, a = $\frac{force}{mass} = \frac{0.01}{0.5}$ = 0.02 m/s^2

Using the equation, $s = ut + \frac{1}{2}at^2$

$$s = 0 \times 10 + \frac{1}{2} \times 0.02 \times 10^2 = 1\ meter$$

Q.23. You might have observed that when you walk on ice you take small steps. Why?

Answer: We are able to walk due to force of friction. Friction is a contact force and arises when two objects are in direct contact with each other. While walking our feet exerts force on the ground pushing it backwards and the ground exerts equal and opposite reaction to our feet helping us to move forward. When we walk on ice, the friction force between the feet and the ice decreases and it causes slipping. Therefore, we take small steps on ice.

Q.24. Why you have to apply more force in moving a cycle which is punctured?

Answer: When the tyre of the cycle is inflated, the pressure inside the tyre is reducing the normal force between tyre and the ground, and thus reducing the friction between the tyre and the road. When the tyre gets punctured, it gets deformed during the rotation of the tyre, the energy supplied is used up in changing the shape and not overcoming the friction, and due to deformation, friction increases. Therefore, we have to apply more force in order to move the cycle.

Q.25. If someone jumps to the shore from a boat, the boat moves in the opposite direction. Why?

Answer: According to Newton's third law, to every action there is equal and opposite reaction. When we jump on the shore from the boat, we are applying force on the boat in the opposite direction in order to move forward and hence the boat moves in the opposite direction.

Q.26. Why fireman finds it difficult to hold a hose, which ejects large amounts of water at a high speed?

Answer: It is difficult for a fireman to hold a hose which ejects large amount of water at high velocity because according to third law of Newton which states that for every action there is an equal and opposite reaction.

As the hose ejects a large amount of water in the forward direction has great force. So, an equal and opposite reaction is applied on the fireman. That is why he finds it difficult to hold the hose. Also, according to law of conservation of momentum, the amount (mass) of water coming out (velocity) produces recoil on the hose. To stop the hose from moving, the fireman has to supply his own force on the hose, and must exert a large quantity of force to counter the hose's recoil.

Q.27. Why you tie the luggage with a rope on the roof of buses?

Answer: Luggage is in contact with the roof of the bus. When the bus is moving the luggage is also in the state of motion and had a tendency to remain in motion due to law of inertia. When the driver apply the brakes, the bus stops suddenly but the luggage is in motion and thus fall from the roof. It is therefore advised to tie the luggage.

Comprehensive Exercises (MCQ)

Q.1. An athlete runs some distance before taking a long jump, because:

A. he gains energy to take him through the long distance

B. it helps to apply larger force

C. by running action and reaction forces increase.

D. by running he gives himself large inertia of motion.

Answer: An athlete runs before jumping to gain momentum because it helps in jumping higher and longer because of inertia of motion gained due to the motion. When the athletes jump, they already have a forward motion that would be greater than that of a jump made from standing in one spot. While running, the athlete cannot gain energy or apply larger force because initially he would be rest and while running, he will lose energy.

Q.2. While dusting a carpet we suddenly jerk or beat it with a stick because:

A. inertia of rest keeps the dust in its position and the dirt is removed by moment of the carpet away

B. inertia of motion removes the dirt

C. no inertia is involved it is due to practical experience

D. none of these

Answer: Dust particles are at rest with respect to the carpet. When the carpet is beaten, the dust due to inertia tends to remain at rest while the carpet moves due to external force applied. So, the dust comes out of the carpet. Inertia of motion is not involved here as the dust particles are at rest and inertia is involved in this case. So, option B. & C. are not the correct option.

Q.3. A man is at rest in the middle of pond on perfectly smooth ice. He can get himself to the shore by making use of Newton's:

A. first law

B. second law

C. third law

D. all the laws

Answer: When the man pushes the ice backward the ice will give an equal reaction in the forward direction and thus helps him to reach the shore. This action reaction law is explained in third law. First law is also known as law of inertia & second law is known as law of force and acceleration.

Q.4. Inertia is that property of a body by virtue of which the body is:

A. unable to change by itself its state of rest

B. unable to change by itself its state of uniform motion

C. unable to change by itself its direction of motion

D. all of these

Answer: According to Newton's law, an object which is at rest or in motion will continue its state of rest or motion unless and until an external force is applied on it. This property is known as inertia.

Q.5. A force can be completely described by:

A. its magnitude

B. its direction

C. its magnitude and direction

D. neither magnitude nor direction

Answer: Force is a vector quantity which can only be explained by both magnitude and its direction.

Q.6. The SI unit of force is:

A. Newton

B. newton per second

C. newton-metre

D. newton per square metre

Answer: One Newton is the force required to accelerate one kilogram of mass at the rate of one metre per Second Square in the direction of the applied force. Newton per second is S.I. unit of impulse. Newton-metre is the unit of torque. Newton per square metre is S.I. unit of pressure.

Q.7. Which of the following has the largest inertia?

A. a pin

B. a pen

C. your physics book

D. your school bag

Answer: School bag has the mass greater than the pin, pen and book. So, it offers greater resistance and hence had higher inertia.

Q. 8 The rate of change of momentum is:

A. velocity

B. acceleration

C. force

D. impulse

Answer: The rate of change of momentum = $\frac{m(v-u)}{t}$

Rate of change of momentum = force applied

$$\text{Force} \propto \frac{m(v-u)}{t}$$

Velocity is rate of change of displacement and acceleration is rate of change of velocity. Impulse is change in momentum.

Q. 9. A jet engine works on the principle of Newton's:

A. first law of motion

B. second law of motion

C. third law of motion

D. none of these

Answer: The combustion of fuel generates a large amount of gas which escapes from backward direction. Due to very high velocity, the backward rushing gases have large momentum. They impart equal and opposite reaction to the jet engine due to which it moves forward with great velocity. First law is law of inertia & second law is law of force and acceleration.

Q.10. Action-reaction forces act:

A. on the same body

B. on different bodies

C. along different lines

D. in the same direction

Answer: According to Newton's third law, to every action there is equal and opposite reaction. But these two forces are acting on two different objects and not on the same object. If the forces act on same object the forces will get cancelled and the object will not move.

Q.11. The acceleration of a body is to be doubled from its initial value. By what factor is the acting force to be increased?

A. half

B. two

C. four

D. one

Answer: Force ∝ acceleration. So, if acceleration is doubled, force will also increase by a factor of two.

Q.12. The momentum of a body of given mass is proportional to its:

A. speed

B. volume

C. density

D. shape

Answer: The property or tendency of a moving object to continue moving is called momentum. For an object moving in a line, the momentum is the mass of the object multiplied by its velocity. Volume, density and shape does not determine the momentum.

Q.13. Newton's second law of motion gives us a measure of:

A. force

B. momentum

C. inertia

D. acceleration

Answer: Newton's second law states that the rate of change of momentum of a body is directly proportional to the force applied, and this change in momentum takes place in the direction of the applied force. First law gives measure of inertia.

Q.14. When a net force acts on an object the object will be accelerated in the direction of force with an acceleration proportional to:

A. force on the object

B. velocity of object

C. mass of object

D. inertia of object

Answer: Force ∝ acceleration. Acceleration is rate of change of velocity. Mass is a constant quantity. Inertia is a tendency to resist the state of rest or motion.

Q.15. The action-reaction forces:

A. must act on the same object

B. may act on same object

C. may act on different objects

D. must act on different objects

Answer: According to Newton's third law, to every action there is equal and opposite reaction. But these two forces are acting on two different objects and not on the same object. If the forces act on same object the forces will get cancelled and the object will not move.

Q.16. A gun recoils after firing to conserve:

A. velocity

B. momentum

C. force

D. speed

Answer: According to law of conservation of momentum, initial momentum is equal to the final momentum. So, in order to conserve momentum, the gun recoils. Velocity, force and speed are not conserved.

Q.17. The quantitative definition of force is given by:

A. Newton's first law of motion

B. Newton's second law of motion

C. Newton's third law of motion

D. Law of conservation of momentum.

Answer: Newton's second law states that the rate of change of momentum of a body is directly proportional to the force applied, and this change in momentum takes place in the direction of the applied force. Newton's first law gives the law of inertia and third law

the action & reaction law. Law of conservation of momentum states that initial momentum is equal to final momentum.

Rate of change of momentum = force applied

$$\text{Force} \propto \frac{m(v-u)}{t}$$

$$\text{Force} = k \frac{m(v-u)}{t}$$ where k = proportionality constant

$$\text{Force} = kma \text{ where a = acceleration} = \frac{m(v-u)}{t}$$

Q.18. The qualitative definition of force is given by:

A. Newton's first law of motion

B. Newton's second law of motion

C. Newton's third law of motion

D. Law of conservation of momentum.

Answer: Newton's first law states that an object at rest will stay at rest and an object in motion will stay in motion with the same speed and direction unless and until an external force is applied on the object. Newton's third law the action & reaction law. Law of conservation of momentum states that initial momentum is equal to final momentum.

Q.19. When balanced forces act on a body, the body is:

A. either at rest or moving with constant velocity

B. moving with variable speed

C. moving with variable velocity

D. accelerating

Answer: Balanced forces acts on an object in opposite directions and are equal in strength. They do not cause a change in the speed of a moving object. For all the other options unbalanced forces are required.

Q.20. If a body experiences a net zero unbalanced force, then body:

A. can be accelerated

B. moves with constant velocity

C. cannot remain at rest

D. none of these

Answer: Zero unbalanced force means the body is not accelerating but it moves with a constant velocity.

Comprehensive Exercises (T/F)

Q.1. Write or false for the following statements:

Force may or may not produce any motion in a body.

Answer: True

A balanced force does not produce any motion but unbalanced force does.

Q.2. Write or false for the following statements:

Action and reaction act on the same body.

Answer: False

According to Newton's third law, to every action there is equal and opposite reaction. But these two forces are acting on two different objects and not on the same object. If the forces act on same object the forces will get cancelled and the object will not move.

Q.3. Write or false for the following statements:

Impulse represents the rate of change of momentum of a body.

Answer: False

Impulse = force $\times$ time = change in momentum

Rate of change of momentum is force applied and not momentum.

Q.4. Write or false for the following statements:

1 N is that force which produces acceleration of 1 m s^{-2} in a body of mass 1 g.

Answer: False

One Newton is the force required to accelerate one kilogram of mass at the rate of one meter per Second Square in the direction of the applied force.

Q.5. Write or false for the following statements:

In any interaction, there are always at least two forces in play.

Answer: True

According to Newton's third law to every action, there is equal and opposite reaction and thus two forces comes into play.

Q.6. Write or false for the following statements:

The force of friction is smaller in solids than in liquids.

Answer: False

Force of friction is greater in solids than in liquids because solids have greater surface area than liquids. More the surface area more is the friction. Moreover, liquids are smooth in comparison to solids and therefore their friction is less.

Q.7. Write or false for the following statements:

The first law of motion is also known as Galileo's law of inertia.

Answer: True

Newton's first law states that an object at rest will stay at rest and an object in motion will stay in motion with the same speed and direction unless and until an external force is applied on the object. This tendency to resist its state of motion is called inertia.