Laws of Motion

2 Marks Answers and Questions

Q1. Give the magnitude and direction of the net force acting on

(a) a drop of rain falling down with constant speed.

(b) a kite skillfully held stationary in the sky.

Ans: (a) As the raindrop is falling at a constant speed, its acceleration will be 0. The net force acting on the raindrop will be 00 because the force acting on a particle is given by.

(b) As the kite is held stationary, by Newton's first law of motion, the algebraic sum of forces acting on the kite is zero.

Q2. Write two consequences of Newton's second law of motion.

Ans: The two consequences of Newton's Second Law of Motion are as follows.

1.It demonstrates that the motion is only accelerated when force is applied to it.

2. It introduces the notion of a body's inertial mass.

Q3. A bird is sitting on the floor of a wire cage, and the cage is in the hand of a boy. The bird starts flying in the cage. Will the boy experience any change in the weight of the cage?

Ans: When the bird begins to fly within the cage, the weight of the bird is no longer felt since the air inside is in direct touch with ambient air, making the cage look lighter.

Q4. Why does a cyclist lean to one side, while going along a curve? In what direction does he lean?

Ans: A cyclist leans while riding along a curve because a component of the ground's natural response supplies him with the centripetal force he needs to turn.

He must lean inward from his vertical posture, towards the circular path's centre.

Q5. A soda water bottle is falling freely. Will the gas bubbles rise to the surface of the water in the bottle?

Ans: As the water in a freely falling bottle is in a state of weightlessness, As a result, there is no upthrust force on the bubbles, and the bubbles do not ascend in the water.

Q6. Explain why passengers are thrown forward from their seats when a speeding bus stops suddenly.

Ans: When a fast bus comes to a complete stop, the bottom half of the body in touch with the seat comes to a complete halt, while the upper section of the passengers' bodies prefer to retain their uniform motion. As a result, the passengers are pushed forward.

Q7. How does road banking reduce tyre wear and tear?

Ans: When a curving road is not banked, friction between the tyres and the road provides centripetal force.

Friction must be increased, resulting in wear and tear. When the curving road is banked, however, a component of the ground's natural response supplies the necessary centripetal force, reducing tyre wear and tear.

Q8. A force is being applied to a body, but it causes no acceleration. What possibilities might be considered to explain the observation?

Ans: (1) If the force is a deforming force, no acceleration is produced.

(2) Internal force is incapable of causing acceleration.

4 Marks Answers and Questions

Q1. Give the magnitude and direction of the net force acting on a stone of mass 0.1 kg

(a) just after it is dropped from the window of a stationary train,

(b) just after it is dropped from the window of a train running at a constant velocity of 36 km/h,

(c) just after it is dropped from the window of a train accelerating with 1 m s−2,

(d) lying on the floor of a train which is accelerating with 1 m s−2, the stone being at rest relative to the train. Neglect air resistance throughout.

Ans: (a) 1 N; vertically downward

From the question, we have the mass of the stone given as, m=0.1 kg

The acceleration of the stone is given as, a = g = 10 m/s2

The net force exerted on the stone, according to Newton's second law of motion, is

F = ma = m g

= 0.1×10 = 1 N

Gravitational acceleration always works in the downward direction.

(b) 1 N; vertically downward

The train is travelling at a constant speed. As a result, its acceleration in the horizontal direction, where it is moving, is zero. As a result, there is no horizontal force acting on the stone.

The net force acting on the stone is due to gravity's acceleration, and it is always vertically downward. This force has a magnitude of 1 N.

(c) 1 N; vertically downward

It is given that the train is accelerating at the rate of 1 m/s2.

Hence, the net force acting on the stone will be equal to, F′ = ma = 0.1×1 = 0.1 N

This force has a horizontal component to it. The horizontal force F′, no longer acts on the stone when it is dropped. This is due to the fact that the force acting on a body at any one time is determined by the current circumstances rather than previous ones.

As a result, the net force acting on the stone is determined only by gravity's acceleration.

F = mg = 1 N

This force acts vertically downward.

(d) 0.1 N; in the direction of motion of the train

The typical reaction of the floor balances the weight of the stone. The train's horizontal motion is the only source of acceleration.

Acceleration of the train, a = 0.1 m/s2

The net force acting on the stone will be directed in the train's direction of travel. Its magnitude is given by:

F = ma

= 0.1×1 = 0.1 N

Q2. Suresh saw a large Granite Rock in his neighbourhood. He believed that if they worked on it, they would be able to make money. He obtained approval from the government and completed all of the necessary paperwork. He used a bomb to (a) Which of Suresh's values do you admire?

(b) A bomb is hurled horizontally at a speed of 50 metres per second. It detonates into two halves, each weighing 6 kg and 3 kg. The heavier piece continues to move horizontally at an average speed of 80 m/s. Calculate the lighter fragment's velocity.

Ans. (a) Suresh understands how to make use of natural resources and is concerned about others. He also understands how to complete all legal requirements prior to beginning any work.

(b) In accordance with the law of conservation of momentum,

Total momentum of fragments = Momentum of the Bomb

m1v1 + m2v2 = MV

⇒ 6 × 80 + 3 × V2 = 9 × 50

⇒ V2 = -10 m/s.

Q3. Define the concepts "momentum" and "impulse" in your own words. In the SI system, what are their units?

Ans. The overall amount of motion held by the body is referred to as momentum. It is equivalent to the product of the body's mass and velocity when calculated mathematically. This is known as linear momentum P in linear motion. It's a quantity with a vector.

mv = p

kg ms-1 or NS in SI units are the units of linear momentum.

The action or impact of force is referred to as the force **impulse**. The product of the force F operating on the body and the time for which the force acts is equal to the impulse J. Thus.

J = F × t = Ft

J is a **vector quantity** with units of Ns or kg ms-1.

When a force or impulse acts for a shorter period of time, its activity is intensified.

Q4. A body of mass 0.40 kg moving initially with a constant speed of 10 ms-1to the north is subject to a constant force of 8.0 N directed towards the south for 30 s. Take the instant the force is applied to be t = 0, the position of the body at that time to be x = 0, and predict its position at t= -5 s, 25 s, 100 s.

Ans. Mass of the body, m= 0.40 kg

Initial speed of the body, u= 10 m/s due north

Force acting on the body, F= $-8.0\ \mathrm{N}$

Acceleration produced in the body, $a=\frac{F}{m}=\frac{-8.0}{0.40}=-20 m/s^2$

(i) At t= -5 s

Acceleration, a'' = 0 and u = 10 m/s

$$s=ut+\frac{1}{2}a't^2$$

= $10\times(-5)=-50\ \mathrm{m}$

(ii) At t= 25 s

Acceleration, a'''' = $-20\ \mathrm{m/s^2}$ and u = 10 m/s

$$s'=ut'+\frac{1}{2}a''t^2$$

$$=10\times25+\frac{1}{2}\times(-20)\times(25)^2$$

$$=250+6250=-6000m$$

(iii) At t= 100 s

For $0\le t\le 30s$

a= $-20\ \mathrm{m/s^2}$

u= 10 m/s

$s_1 = ut + \frac{1}{2}a''t^2$

$= 10 \times 30 + \frac{1}{2} \times (-20) \times (30)^2$

$= 300 - 9000$

$= -8700m$

For $30' < t \leq 100s$

As per the first equation of motion, for t= 30 s, final velocity is given as:

v= u + at

= $10 + (-20) \times 30 = -590\ \mathrm{m/s}$

Velocity of the body after 30 s = $-590\ \mathrm{m/s}$

For motion between 30 s to 100 s, i.e., in 70 s:

$s_2 = vt + \frac{1}{2}a''t^2$

$= -590 \times 70 = -41300m$

$= -590 \times 70 = -41300\ \mathrm{m}$

∴ Total distance, $s'' = s_1 + s_2 = -8700 - 41300 = -50000m$

7 Marks Answers and Questions

Q1. A helicopter of mass 1000 kg rises with a vertical acceleration of 15 ms−2. The crew and the passengers each weigh 300 kg. Give the magnitude and direction of the

(a) force on the floor by the crew and passengers,

(b) action of the rotor of the helicopter on the surrounding air,

(c) force on the helicopter due to the surrounding air.

Ans: (a) Mass of the helicopter is given as, mh= 1000 kg

Mass of the crew and passengers is given as, mp= 300 kg

Therefore, the total mass of the system, m = 1300 kg

As the acceleration of the helicopter is given as, a = 15 m/s2

The reaction force R exerted on the system by the floor may be computed using Newton's second equation of motion.

R−mpg = ma

= mp(g+a)

= 300(10+15) = 300×25

= 7500 N

The response force will likewise be directed upward because the helicopter is accelerating vertically.As a result, the force exerted on the floor by the crew and passengers is 7500 N, directed downward, according to Newton's third law of motion.

(b) The reaction force R experienced by the helicopter may be computed using Newton's second equation of motion as follows = 32500 N

The helicopter is being pushed higher by the reaction force of the surrounding air. As a result, the rotor's action on the surrounding air will be 32500N, directed downward, according to Newton's third law of motion.

(c) The surrounding air exerts a force of 32500N on the helicopter, which is directed upward.

Q2. A stream of water is flowing horizontally with a speed of 15 ms−1. It gushes out of a tube of cross-sectional area 10−2 m2, and hits a vertical wall nearby. Calculate what is the force exerted on the wall by the impact of water, assuming it does not rebound.

Ans. The speed of the water stream is given as v = 15 ms−1

The cross-sectional area of the tube (A) = 10−2 m2

Thus, the volume of water coming out from the pipe per second will be

V = A v = 15 × 10−2 m3 s−1

We know that the density of water is p = 103 kgm−3

Flow Rate of water through the pipe in gallons per second will be

p × V = 150 kgs−1

The water does not bounce back when it hits the wall. Here, as a result, **Newton's second law of motion** gives the force exerted by the water on the wall as

F = Rate of change of momentum = ΔP/Δt = mv/t

= 150 × 15 = 2250 N

Q3. Are there different ways to reduce friction?

Ans. Friction reduction saves a significant amount of energy. The following are some of the strategies for minimising friction:

- Smoothing the surfaces using a variety of techniques, such as:
  - scraping the surfaces and polishing them
  - Using smooth materials such as metal foils or solar mica to cover the surface.
  - Using lubricating fluids and other materials, such as granite, to lubricate the surfaces.
- The irregularities, grooves, and other faults in the surface are filled with these methods, and the surface becomes smooth. Grease, for instance, is used to reduce friction in many devices.
- Streamlining the shape of bodies: Streamlining the shape of bodies reduces friction. To reduce fluid friction, high-speed vehicles, railway engines, ships, boats, and aeroplanes, for example, are designed with streamlines. It not only decreases friction but also aids in the application of pushing power.
- Making modifications to convert sliding to **rolling friction**: Because rolling friction is much less than **sliding friction**, several machine parts are designed with rolling friction. Ball bearings are utilised in bicycle and machine shafts, for example. For the same reason, the vehicles use wheels rather than sliding arrangements.

Q4. A railway car with a mass of 20 tonnes moves with an initial speed of 54 km/hr. When the brakes are applied, a constant negative acceleration of 0.3 m/s2 is produced.

i. **Calculate what is the breaking force acting on the car?**
ii. **At what time will the car stop?**
iii. **Calculate the distance that will be covered by the car before it finally stops?**

Ans. m = 20 tonnes = 20 × 1000 kg

u = 54 km hr−1 = 15 ms−1

a = −0.3 ms-2 and ϑ = 0

(i) F = ma

F = 20000 × (−0.3)

F = −6000 N

(ii) v = u + at

v − u = at

t = (v − u)/a = (0−15)/(−0.3)

t = 50 s

(iii) v2 − u2 = 2as

(0)2 − (15)2 = 2 (−0.3) s

s = 375 m

Multiple Choice Questions

1. **A ball is travelling with uniform translatory motion. This means that**
(a) it is at rest.
(b) the path can be a straight line or circular and the ball travels with uniform speed.
(c) all parts of the ball have the same velocity (magnitude and direction) and the velocity is constant.
(d) the centre of the ball moves with constant velocity and the ball spins about its centre uniformly.

Answer:(c) all parts of the ball have the same velocity (magnitude and direction) and the velocity is constant.

2. **Conservation of momentum in a collision between particles can be understood from**
(a) conservation of energy.
(b) Newton's first law only.
(c) Newton's second law only.
(d) both Newton's second and third law

Answer:(d) both Newton's second and third law

3. **A block of mass 2 kg is placed on a plane surface. The coefficient of static friction is .4. When a 2.8 N force is applied on the block parallel to the surface,the force of friction between the vlock and surface is**
(a) 2.8 N
(b) 7.84 N
(c) 0
(d) 9 N

Answer: (a) 2.8 N

4. **A body of mass 3kg travels according to the law $x=at+bt^2+ct^3$**
where a=3 m/s , b=4 m/s^2 , c= 5 m/s^3
The force acting on the body at t = 2 seconds is
(a) 136 N
(b) 204 N
(c) 158 N
(d) 68 N

Answer:(b) 204 N

5. **The coefficient of friction between the two contact plane is √3 ,what is the angle of friction between those two planes?**
(a). 30°
(b) 60°
(c) 15 °
(d) 45°

Answer:(b) 60°

6. **In a circus ,a motor cyclist goes round a circular track of radius r in a vertical plane. At the highest point on his track,the minimum velocity is**

(a) √2gr
(b) √gr
(c) √3gr
(d) 2√gr

Answer:(b) √gr

7.A block of mass 10 kg is sliding downwards on a inclined plane of angle 30° with horizontal. The coefficient of kinetic friction between the block and surface is .5. Find the accleration of the block (take g=9.8 m/s^2)

(a) .571 m/s^2
(b) .511 m/s^2
(c) .657 m/s^2
(d) .651 m/s^2

Answer:(c) .657 m/s^2

8.Inertia is the property of a body linked to tendency of a body
(a) to change its position
(b) to change its direction
(c) to change the momentum
(d) to resist any change in its state

Answer:(d) to resist any change in its state

9. **Force depends on**
(a) change in momentum
(b) how fast the change in momentum is brought about
(c) Both (a) & (b)
(d) None of these

Answer:(c) Both (a) & (b)

10. **Physical independence of force is a consequence of**
(a) third law of motion
(b) second law of motion
(c) first law of motion
(d) all of these

Answer:(c) first law of motion

Fill in the blanks:

(1) The tendency of a body to resist acceleration is called …….. .

Ans: The tendency of a body to resist acceleration is called inertia.

(2) In the SI system, ……. is the unit of force.

Ans: In the SI system, Newton is the unit of force.

(3) In a collision …… is always conserved.

Ans: In a collision momentum is always conserved.

(4) The motion of rocket is based on Newton's …… law of motion.

Ans: The motion of rocket is based on Newton's third law of motion.

(5) An …… force acting on an object brings it in motion.

Ans: An unbalanced force acting on an object brings it in motion.

(6) external force….. To keep a body…. According to….. .

Ans:external force is required To keep a body in uniform motion According to Aristotle .

(7) Linear momentum of a body is defined as….. .

Ans:Linear momentum of a body is defined as product of mass of body and its velocity .

(8) The net force on a body is equal to…… and…… .

Ans:The net force on a body is equal to product of mass of the body and acceleration of the body.

(9) Acceleration of a body can be……. Only if…….

Ans:Acceleration of a body can be non zero Only if the unbalanced force acting on the body is non-zero.

(10) Impulse of a force is …….and…… .

Ans: Impulse of a force is product of force and time for which force acts.