Chapter 1
Laws of Motion

I. Choose the correct Answer

Question 1.
Inertia of a body depends on:
(a) weight of the object
(b) acceleration due to gravity of the planet
(c) mass of the object
(d) both (a) & (b)
Answer:
(c) mass of the object

Question 2.
Impulse is equals to _____ .
(a) rate of change of momentum
(b) rate of force and time
(c) change of momentum
(d) rate of change of mass.
Answer:
(c) change of momentum

Question 3.
Newton's III law is applicable:
(a) for a body is at rest
(b) for a body in motion
(c) both (a) & (b)
(d) only for bodies with equal masses
Answer:
(b) for a body in motion

Question 4.
Plotting a graph for momentum on the X-axis and time on Y-axis. Slope of momentum – time graph gives _____
(a) Impulsive force
(b) Acceleration
(c) Force
(d) Rate of force.
Answer:
(c) Force

Question 5.
In which of the following sport the turning effect of force is used?
(a) swimming
(b) tennis
(c) cycling
(d) hockey
Answer:
(c) cycling

Question 6.
The unit of 'g' is ms^{-2}. It can be also expressed as:
(a) $cm\ s^{-2}$
(b) $N\ kg^{-1}$
(c) $N\ m^2kg^{-1}$
(d) cm^2s^{-2}
Answer:
(a) $cm\ s^{-2}$

Question 7.
One kilogram force equals to _____ .
(a) 9.8 dyne
(b) 9.8×10^4 N
(c) 98×10^4 dyne
(d) 980 dyne.
Answer:
(c) 98×10^4 dyne

Question 8.
The mass of a body is measured on planet Earth as M kg. When it is taken to a planet of radius half that of the Earth then its value will be ….. kg.
(a) 4 M
(b) 2 M
(c) M/4
(d) M
Answer:
(c) M/4

Question 9.
If the Earth shrinks to 50% of its real radius its mass remaining the same, the weight of a body on the Earth will:
(a) decrease by 50%
(b) increase by 50%
(c) decrease by 25%
(d) increase by 300%
Answer:
(c) decrease by 25%

Question 10.
To project the rockets which of the following principle(s) is / (are) required?
(a) Newton's third law of motion
(b) Newton's law of gravitation
(c) law of conservation of linear momentum
(d) both a and c.
Answer:
(d) both a and c.

II. Fill in the blanks

1. To produce a displacement …….. is required.
2. Passengers lean forward when the sudden brake is applied in a moving vehicle. This can be explained by …….
3. By convention, the clockwise moments are taken as …… and the anticlockwise moments are taken as …….
4. …….. is used to change the speed of the car.
5. A man of mass 100 kg has a weight of …….. at the surface of the Earth.

Answer:

1. force
2. inertia
3. negative, positive
4. Accelerator
5. Weight = m × g = 100 × 9.8 = 980 N

III. State whether the following statements are true or false. Correct the statement if it is false.

1. The linear momentum of a system of particles is always conserved.
2. Apparent weight of a person is always equal to his actual weight.
3. Weight of a body is greater at the equator and less at the polar region.
4. Turning a nut with a spanner having a short handle is so easy than one with a long handle.
5. There is no gravity in the orbiting space station around the Earth. So the astronauts feel weightlessness.

Answer:

1. True
2. False – Apparent weight of a person is not always equal to his actual weight.
3. False – Weight of a body is minimum at the equator. It is maximum at the poles.
4. False – Turning a nut with a spanner having a longer handle is so easy than one with a short handle.

5. False – Astronauts are falling freely around the earth due to their huge orbital velocity.

IV. Match the following.

Column I		Column II	
A	Newtons's I law	*(i)*	Propulsion of a rocket
B	Newtons's II law	*(ii)*	Stable equilibrium of a body
C	Newtons's III law	*(iii)*	Law of force
D	Law of conservation of Linear momentum.	*(iv)*	Flying nature of bird

Answer:
A. (ii)
B. (Hi)
C. (iv)
D. (i)

V. Assertion and Reasoning.

Mark the correct choice as:
(a) If both the assertion and the reason are true and the reason is the correct explanation of assertion.
(b) If both the assertion and the reason are true, but the reason is not the correct explanation of the assertion.
(c) Assertion is true, but the reason is false.
(d) Assertion is false, but the reason is true.
1. Assertion: The sum of the clockwise moments is equal to the sum of the anticlockwise moments.
Reason: The principle of conservation of momentum is valid if the external force on the system is zero.
2. Assertion: The value of 'g' decreases as height and depth increases from the surface of the Earth.
Reason: 'g' depends on the mass of the object and the Earth.
Answer:
1. (b)
2. (c)

VI. Answer Briefly.

Question 1.
Define inertia. Give its classification.
Answer:

The inherent property of a body to resist any change in its state of rest or the state of uniform motion, unless it is influenced upon by an external unbalanced force, is known as 'inertia'.
Classifications:

1. Inertia of rest
2. Inertia of motion
3. Inertia of direction

Question 2.
Classify the types of force based on their application.
Answer:
Based on the direction in which the forces act, they can be classified into two types as:

1. Like parallel forces: Two or more forces of equal or unequal magnitude acting along the same direction, parallel to each other are called like parallel forces.
2. Unlike parallel forces: If two or more equal forces or unequal forces act along with opposite directions parallel to each other, then they are called, unlike parallel forces.

Question 3.
If a 5 N and a 15 N forces are acting opposite to one another. Find the resultant force and the direction of action of the resultant force.
Answer:
$F_1 = 5$ N
$F_2 = 15$ N
∴ Resultant force $F_R = F_1 - F_2$
$= 5 - 15 = -10$ N
It acts in the direction of the force of 15 N (F_2).

Question 4.
Differentiate mass and weight.
Answer:
Ratio of masses of planets is
$m_1 = m_2 = 2 : 3$
Ratio of radii
$R_1 = R_2 = 4 : 7$
We know

$$\frac{GM}{R^2}$$

$$\therefore g \propto \frac{M}{R^2}$$

$$\therefore g_1 \propto \frac{M_1}{R_1^2} \text{ and } g_2 \propto \frac{M_2}{R_2^2}$$

Ratio of acceleration due to gravity

$$\frac{g_1}{g_2} = \frac{M_1}{R_1^2} \times \frac{R_2^2}{M_2}$$

$$\therefore \frac{g_1}{g_2} = \frac{M_1}{M_2} \times \left(\frac{R_2}{R_1}\right)^2$$

$$= \frac{2}{3} \times \left(\frac{7}{4}\right)^2 = \frac{2}{3} \times \frac{49}{16} = \frac{49}{24}$$

Question 5.
Define the moment of a couple.
Answer:
When two equal and unlike parallel forces applied simultaneously at two distinct points constitute a couple. A couple results in causes the rotation of the body. This rotating effect of a couple is known as the moment of a couple.

Question 6.
State the principle of moments.
Answer:
Principle of moments states that if a rigid body is in equilibrium on the action of a number of like (or) unlike parallel forces then the algebraic sum of the moments in the clockwise direction is equal to the algebraic sum of the moments in the anticlockwise direction.

Question 7.
State Newton's second law.
Answer:
The force acting on a body is directly proportional to the rate of change of linear momentum of the body and the change in momentum takes place in the direction of the force.

Question 8.
Why a spanner with a long handle is preferred to tighten screws in heavy vehicles?
Answer:
When a spanner is having a long handle, the turning effect of the applied force is more when the distance between the fixed edge and the point of application of force is more. Hence a spanner with a long handle is preferred to tighten screws in heavy vehicles.

Question 9.
While catching a cricket ball the fielder lowers his hands backwards. Why?
Answer:

While catching a cricket ball the fielder lowers his hands backwards, so increase the time during which the velocity of the cricket ball decreases to zero. Therefore the impact of force on the palm of the fielder will be reduced.

Question 10.
How does an astronaut float in a space shuttle?
Answer:
Astronauts are not floating but falling freely around the earth due to their huge orbital velocity. Since spaceshuttle and astronauts have equal acceleration, they are under free fall condition. (R = 0) Hence, both the astronauts and the space station are in the state of weightlessness.

VII. Solve the given problems.

Question 1.
Two bodies have a mass ratio of 3 : 4 The force applied on the bigger mass produces an acceleration of 12 ms^2. What could be the acceleration of the other body, if the same force acts on it.
Answer:
Ratio of masses $m_1 : m_2 = 3 : 4$

Acceleration of m_2 is $a_2 = 12\ m/s^2$

Force acting of m_2 is $F_2 = m_2a_2$

$F_2 = 4 \times 12 = 48N$

but $F_2 = F_1$

$\therefore$ Force acting on m_1 is $F_1 = 48N$

$\therefore$ Acceleration of $m_1 = a_1 = \frac{F_1}{m_1}$

$a_1 = \frac{48}{3}$

$= 16\ m/s^2$

Acceleration of the other body ax = $16\ m/s^2$

Question 2.
A ball of mass 1 kg moving with a speed of 10 ms-1 rebounds after a perfect elastic collision with the floor. Calculate the change in linear momentum of the ball.
Answer:
Given mass = 1 kg, speed = 10 ms^{-1}
Initial momentum = mu = 1 × 10 = 10 kg ms^{-1}
Final momentum = -mu = -10 kg ms^{-1}
Change in momentum = final momentum – initial momentum = -mu – mu
Change in momentum = -20 kg ms^{-1}

Question 3.
A mechanic unscrew a nut by applying a force of 140 N with a spanner of length 40 cm. What should be the length of the spanner if a force of
40 N is applied to unscrew the same nut?
Answer:
Force acting on the screw $F_1 = 140$ N
Length of a spanner $d_1 = 40 \times 10^{-2}$ m
Second force applied to the screw $F_2 = 40$ N
Let the length of spanner be d_2
According to the Principle of moments,
$F_1 \times d_1 = F_2 \times d_2$
$= 140 \times 40 = 40 \times d_2$
$\therefore d_2 = \frac{140 \times 40}{40}$
$= 140 \times 10^{-2}$ m
Length of a spanner $= 140 \times 10^{-2}$ m

Question 4.
The ratio of masses of two planets is 2 : 3 and the ratio of their radii is 4 : 7. Find the ratio of their accelerations due to gravity.
Answer:
Ratio of masses of two planets is
$m_1 : m_2 = 2 : 3$
Ratio of their radii,
$R_1 : R_2 = 4 : 7$
We know g
Img 2
$\therefore g_1 : g_2 = 49 : 24$

VIII. Answer in Detail.

Question 1.
What are the types of inertia? Give an example for each type.
Answer:
Types of Inertia:
(i) Inertia of rest: The resistance of a body to change its state of rest is called inertia of rest.
E.g.: When you vigorously shake the branches of a tree, some of the leaves and fruits are detached and they fall down (Inertia of rest).

(ii) The inertia of motion: The resistance of a body to change its state of motion is called inertia of motion.
E.g.: An athlete runs some distance before jumping. Because this will help him jump longer and higher. (Inertia of motion)

(iii) Inertia of direction: The resistance of a body to change its direction of motion is called inertia of direction.

E.g.: When you make a sharp turn while driving a car, you tend to lean sideways, (Inertia of direction).

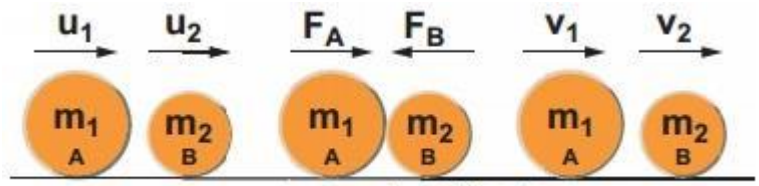
Question 2.
State Newton's laws of motion.
Answer:
(i) Newton's First Law : States that "every body continues to be in its state of rest or the state of uniform motion along a straight line unless it is acted upon by some external force".

(ii) Newton's Second Law : States that "the force acting on a body is directly proportional to the rate of change of linear momentum of the body and the change in momentum takes place in the direction of the force".

(iii) Newton's third law : States that "for every action, there is an equal and opposite reaction. They always act on two different bodies".

Question 3.
Deduce the equation of a force using Newton's second law of motion.
Answer:
Let, 'm' be the mass of a moving body, moving along a straight line with an initial speed V. After a time interval of 't', the velocity of the body changes to v due to the impact of an unbalanced external force F.
Initial momentum of the body $P_i = mu$
Final momentum of the body $P_f = mv$
Change in momentum $\Delta p = P_i - P_f - mv - mu$
By Newton's second law of motion,
Force, F ∝ rate of change of momentum
F ∝ change in momentum / time
$F \propto \frac{mv-mu}{t}$
$F = \frac{km(v-u)}{t}$
Here, k is the proportionality constant.
k = 1 in all systems of units. Hence,
$F = \frac{m(v-u)}{t}$
Since,
acceleration = change in velocity/time,
a = (v – u)/t.
Hence, we have F = m × a
Force = mass × acceleration

Question 4.
State and prove the law of conservation of linear momentum.
Answer:



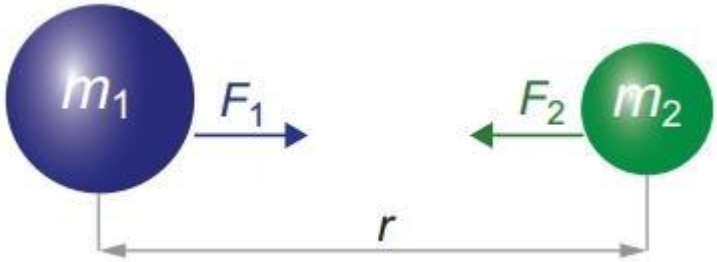
Proof:
Let two bodies A and B having masses m_1 and m_2 move with initial velocity u_1 and u_2 in a straight line. Let the velocity of the first body be higher than that of the second body, i.e,, $u_1 > u_2$. During an interval of time t second, they tend to have a collision. After the impact, both of them move along the same straight line with a velocity v_1 and v_2 respectively.
Force on body B due to A,
$F_B = m_2(v_2 - u_2)/t$
Force on body A due to B,
$F_A = m_1(v_1 - u_1)/t$
By Newton's III law of motion,
Action force = Reaction force
$F_A = -F_B$
$m_1(v_1 - u_1)/t = -m_2 (v_2 - u_2)/t$
$m_1 v_1 + m_2 v_2 = m_1 u_1 + m_2 u_2$
The above equation confirms in the absence of an external force, the algebraic sum of the momentum after collision is numerically equal to the algebraic sum of the momentum before collision.
Hence the law of conservation of linear momentum is proved.

Question 5.
Describe rocket propulsion.
Answer:

1. Propulsion of rockets is based on the law of conservation of linear momentum as well as Newton's III law of motion.
2. Rockets are filled with fuel (either liquid or solid) in the propellant tank. When the rocket is fired, this fuel is burnt and hot gas is ejected with high speed from the nozzle of the rocket, producing a huge momentum.
3. To balance this momentum, an equal and opposite reaction force is produced in the combustion chamber, which makes the rocket project forward.
4. While in motion, the mass of the rocket gradually decreases, until the fuel is completely burnt out.
5. Since there is no net external force acting on it, the linear momentum of the system is conserved.
6. The mass of the rocket decreases with altitude, which results in the gradual increase in the velocity of the rocket.
7. At one stage, it reaches a velocity, which is sufficient to just escape from the gravitational pull of the Earth. This velocity is called escape velocity.

Question 6.
State the universal law of gravitation and derive its mathematical expression.
Answer:
Newton's universal law of gravitation states that every particle of matter in this universe attracts every other particle with a force. This force is directly proportional to the product of their masses and inversely proportional to the square of the distance between the centres of these masses. The direction of the force acts along the line joining the masses.

Force between the masses is always attractive and it does not depend on the medium where they are placed.



Let, m_1 and m_2 be the masses of two bodies A and B placed r metre apart in space
Force
$F \propto m_1 \times m_2$
$F \propto 1/r^2$
On combining the above two expressions

$$F \propto \frac{m_1 \times m_2}{r^2}$$

$$F = \frac{G m_1 m_2}{r^2}$$

Where G is the universal gravitational constant. Its value in SI unit is 6.674×10^{-11} N m^2 kg^{-2}.

Question 7.
Give the applications of gravitation.
Answer:

1. Dimensions of the heavenly bodies can be measured using the gravitation law. Mass of the Earth, the radius of the Earth, acceleration due to gravity, etc. can be calculated with higher accuracy.
2. Helps in discovering new stars and planets.
3. One of the irregularities in the motion of stars is called 'Wobble' lead to the disturbance in the motion of a planet nearby. In this condition, the mass of the star can be calculated using the law of gravitation.
4. Helps to explain germination of roots is due to the property of geotropism, which is the property of a root responding to the gravity.
5. Helps to predict the path of the astronomical bodies.

IX. HOT Questions.

Question 1.
Two blocks of masses 8 kg and 2 kg respectively lie on a smooth horizontal surface in contact with one other. They are pushed by a horizontally applied force of 15 N. Calculate the force exerted on the 2 kg mass.
Answer:
Mass of first block $m_1 = 8$ kg
Mass of second block $m_2 = 2$ kg
Total mass $M = 8 + 2 = 10$ kg
Force applied $F = 15$ N
$\therefore$ Acceleration $a = \frac{F}{M}$
$\frac{15}{10} = 1.5\ m/s^2$
Force exerted on the 2 kg mass,
$F = ma$
$= 2 \times 1.5 = 3$ N

Question 2.
A heavy truck and bike are moving with the same kinetic energy. If the .mass of the truck is four times that of the bike, then calculate the ratio of their momenta. (Ratio of momenta = 1 : 2)
Answer:
Let the mass of truck be m_1
Let the mass of bike be m_2

$m_1 = 4m_2$

$\therefore \frac{m_1}{m_2} = 4$

Kinetic energy $K.E_1 = K.E_2$

$\therefore m_2, v_1^2 = m_2 v_1^2$

$$\left(\frac{v_1}{v_2}\right)^2 = \left(\frac{m_2}{m_1}\right)$$

$$\frac{v_1}{v_2} = \left(\frac{m_2}{m_1}\right)^{1/2}$$

$$\frac{v_1}{v_2} = \left(\frac{m_2}{4m_2}\right)^{1/2} = \frac{1}{2}$$

Ratio of momenta be $P_1 : P_2$

$$\frac{P_1}{P_2} = \left(\frac{m_1}{m_2}\right)\left(\frac{v_1}{v_2}\right)$$

$$\frac{P_1}{P_2} = (4) \times \left(\frac{1}{2}\right) = \frac{2}{1}$$

$\therefore$ Ratio of their momenta = 2 : 1

Question 3.
"Wearing helmet and fastening the seat belt is highly recommended for safe journey" Justify your **Answer** using Newton's laws of motion.
Answer:
(i) According to Newton's Second Law, when you fall from a bike on the ground with a force equal to your mass and acceleration of the bike.
According to Newton's Third Law, an equal and opposite reacting force on the ground is exerted on your body. When you do not wear a helmet, this reacting force can cause fatal head injuries. So it is important to wear helmet for a safe journey.

(ii) Inertia in the reason that people in cars need to wear seat belts. A moving car has inertia, and so do the riders inside it. When the driver applies the brakes, an unbalanced force in applied to the car. Normally the bottom of the seat applies imbalanced force friction which slows the riders down as the car slows. If the driver stops the car suddenly, however, this force is not exerted over enough time to stop the motion of the riders. Instead, the riders continue moving forward with most of their original speed because of their inertia.