Chapter 1: Laws of motion

Q. 1. Fill in the blanks

(1) The minimum distance between the start and finish points of the motion of an object is called the **displacement** of the object.
(2) Deceleration is **negative** acceleration.
(3) When an object is in uniform circular motion, its **velocity** changes at every point.
(4) During collision **total momentum** remains constant.
(5) The working of a rocket depends on Newton's **third** law of motion.
(6) The SI unit of deceleration is **m/s^2**
(7) The CGS unit of momentum is **gm.cm/s**
(8) The SI unit of force is the **Newton**
(9) Force = Rate of change of **momentum**
(10) **Momentum** = mass x velocity.

Q. 2. Write units of:

Quantities	**Units**
Distance	m
Displacement	m
Speed	m/s
Velocity	m/s
Acceleration	m/s^2

Q. 3. Match the following:

[1] Column	**Answer**	**Options**
(1) Positive acceleration	The velocity of object increases	**a. The velocity of object decreases**
(2) Negative acceleration	The velocity of object decreases	**b. The velocity of object increases**
(3) Zero acceleration	The velocity of object remains constant	**c. The velocity of object remains constant**

Q. 4. Write weather is the given quantities is scalar quantities or vector quantities

Quantities	**Type of quantities**
(1) Distance	Scalar
(2) Displacement	Vector
(3) Speed	Scalar
(4) Velocity	Vector

(5) Acceleration	Vector

Q. 4. Answer in one sentence:

(1) Define motion.
Answer: If the object is changing its position with relative to the surrounding then the object is said to be in motion.
(2) Define distance.
Answer: The length of the actual path covered by the object in motion is called distance.
(3) Define displacement.
Answer: The minimum distance between the start point and the end point is called the displacement of the object.
(4) Define speed.
Answer: The distance cover by an object in unit time is called velocity.
(5) Define velocity.
Answer: The displacement that occurs in unit time is called velocity.
(6) Define acceleration.
Answer: The rate of change of velocity is called acceleration.
(7) Define unit of force, Newton.
Answer: The force necessary to cause an acceleration of 1 m/s^2 in an object of mass 1 kg is called 1 newton.
(8) Define momentum.
Answer: Momentum is the product of mass and velocity of an object.
(9) Define Newton First law of motion.
Answer: An object continues to remain at rest or in a state of uniform motion along a straight line unless an external unbalanced force acts on it.
(10) Define Newton second law of motion.
Answer: The rate of change of momentum is proportional to the applied force and the change of momentum occurs in the direction of the force.
(11) Define Newton third law of motion.
Answer: Every action force has an equal and opposite reaction force which acts simultaneously.

Q.5. Difference between.
(1) Distance and Displacement

Distance	**Displacement**
The length of the actual path covered by the object in motion	The minimum distance between the start point and the end point
It is scalar	It is vector
It depends on the path taken	Independent of the path, depends only on initial and final points
A car moves 10 km around a circular track	The car's displacement after completing the circle is 0 km

(2) Speed and Velocity

Speed	**Velocity**
Rate at which an object covers distance	Rate at which an object covers distance
It is scalar	It is vector
Speed = Distance / Time	Velocity = Displacement / Time
A car moving at 60 km/h	A car moving at 60 km/h east

(3) Uniform and non-uniform motion

Uniform motion	**Non-uniform motion**
Motion where an object covers equal distances in equal intervals of time	Motion where an object covers unequal distances in equal intervals of time
Speed is constant throughout the motion	Speed varies throughout the motion
Acceleration is zero	Acceleration can be positive or negative
Distance-Time graph is Straight line	Distance-Time graph is curved line
A car moving at a constant speed of 60 km/h	A car accelerating from 0 to 100 km/h

Q. 6. Give reason

(1) When an object falls freely to the ground, its acceleration is uniform.

Answer: The object experiences a constant acceleration due to gravity, which is approximately 9.8 m/s^2. This uniform acceleration occurs because gravity is constant near Earth's surface.

(2) Even though the magnitudes of action force and reaction force are equal and their directions are opposite, their effects do not get cancelled.

Answer: Action and reaction forces act on two different bodies, so they do not cancel each other. Instead, each force impacts the object on which it is applied.

(3) It is easier to stop a tennis ball as compared to a cricket ball, when both are traveling with the same velocity.

Answer: The cricket ball has a higher mass, giving it more momentum than the tennis ball at the same velocity. Greater momentum requires a larger force to stop the cricket ball compared to the tennis ball.

(4) The velocity of an object at rest is considered to be uniform.

Answer: An object at rest has zero velocity, and since there is no change in velocity, it is constant. Hence, the velocity remains uniform over time.

Q. 7. Answer the Following Question:

(1) Write the five implementations of Newton’s First law of motion.

Answer:

1. A book on a table remains at rest unless acted upon by an external force.
2. A rolling ball eventually stops due to friction.
3. Passengers in a moving car feel a jerk when the car suddenly stops.
4. A spacecraft in space continues to move without propulsion.
5. Dust particles are removed from a carpet by shaking it.

(2) Write the five implementations of Newton’s Second law of motion.

Answer:

1. Pushing a light object is easier than pushing a heavy object.
2. A car accelerates faster when more force is applied to the gas pedal.
3. Kicking a football versus kicking a stone.
4. A loaded truck accelerates slower than an empty truck with the same engine power.
5. The motion of a rocket during liftoff.

(3) Write the five implementations of Newton's Third law of motion.

Answer:

1. Walking on the ground.
2. A rocket launching into space.
3. Recoil of a gun.
4. A swimmer pushing water backwards.
5. Air escaping from a balloon.

(4) Write five examples of uniform circular motion.

Answer:

1. A satellite orbiting the Earth.
2. A car driving around a circular track at constant speed.
3. A ceiling fan rotating at a constant speed.
4. A stone tied to a string being swung in a circle.
5. The motion of a Ferris wheel turning at a constant rate.

(6) Explain the term "balanced force"

Answer: Balanced forces are equal in magnitude but opposite in direction, acting on an object in such a way that they cancel each other out. When forces are balanced, there is no change in the object's motion; if it is at rest, it stays at rest, and if it's moving, it continues to move at constant velocity. For example, a book resting on a table experiences balanced forces—the force of gravity pulling it down is balanced by the table pushing it up. In this case, the net force is zero, resulting in no change in motion.

(7) Explain the term "unbalanced force"

Answer: Unbalanced forces occur when the magnitude of forces acting on an object are not equal, or they are not opposite. This results in a net force on the object, causing it to accelerate, change direction, or change its state of motion. For example, if you push a stationary box and it starts moving, the force you apply is unbalanced because it overcomes friction. This causes the box to move, indicating that the net force is not zero.

(8) Obtain the relation between Newton and Dyne.

Answer:

Force = mass x acceleration

1 Newton = 1kg x 1m/s^2

= 1000g x 10^2 cm/s^2

= 100000 x g.cm/s^2

= 10^5 g.cm/s^2

Now

1 dyne = 1 g x 1m/s^2

= 1 g.cm/s^2

1 Newton = 10^5 dynes

Q. 8. Solve:

(1) An object moves 18 m in the first 3 s, 22 m in the next 3 s and 14 m in the last 3 s. What is its average speed?

Given:

- Distance in first 3 s = 18 m
- Distance in next 3 s = 22 m

- Distance in last 3 s = 14 m
- Total time = 3 s + 3 s + 3 s = 9 s

To Find:
Average speed
Formula:
Average speed = Total distance / Total time
Calculation:
Total distance = 18 m + 22 m + 14 m = 54 m
Average speed = 54 m / 9 s = 6 m/s
Answer:
Average speed = 6 m/s

(2) A person swims 100 m in the first 40 s, 80 m in the next 40 s and 45 m in the last 20 s. What is the average speed?
Given:
- Distance in first 40 s = 100 m
- Distance in next 40 s = 80 m
- Distance in last 20 s = 45 m
- Total time = 40 s + 40 s + 20 s = 100 s

To Find:
Average speed
Formula:
Average speed = Total distance / Total time
Calculation:
Total distance = 100 m + 80 m + 45 m = 225 m
Average speed = 225 m / 100 s = 2.25 m/s
Answer:
Average speed = 2.25 m/s

(3) An athlete is running on a circular track. He runs a distance of 400 m in 25 s before returning to his original position. What is his average speed and velocity?
Given:
- Distance covered = 400 m
- Time taken = 25 s
- Initial and final positions are the same (he returns to the original position)

To Find:
Average speed and average velocity
Formulas:
- Average speed = Total distance / Total time
- Average velocity = Total displacement / Total time

Calculation:
- Average speed = 400 m / 25 s = 16 m/s
- Total displacement = 0 m (since he returns to the original position)
- Average velocity = 0 m / 25 s = 0 m/s

Answer:
- Average speed = 16 m/s
- Average velocity = 0 m/s

(4) A bullet having a mass of 10 g and moving with a speed of 1.5 m/s, penetrates a thick wooden plank of mass 900 g. The plank was initially at rest. The bullet gets embedded in the plank and both move together. Determine their velocity.
Given:
- Mass of the bullet (m_1) = 10 g = 0.01 kg (convert to kg)
- Speed of the bullet (v_1) = 1.5 m/s
- Mass of the plank (m_2) = 900 g = 0.9 kg (convert to kg)
- Initial speed of the plank (v_2) = 0 m/s (at rest)

To Find:
Velocity after collision (v)
Formula:
Using the principle of conservation of momentum:
$m1 \cdot v1 + m2 \cdot v2 = (m1 + m2) \cdot v$
Calculation:
$m1 \cdot v1 + m2 \cdot v2 = (m1 + m2) \cdot v$
$(0.01kg \cdot 1.5m/s) + (0.9kg \cdot 0m/s) = (0.01kg + 0.9kg) \cdot v$
$0.015kg\ m/s = 0.91kg \cdot v$
$v = \frac{0.015kg\ m/s}{0.91kg} \approx 0.0165m/s$
Answer:
Velocity after collision $v \approx 0.0165m/s$

(5) An object of mass 16 kg is moving with an acceleration of 3 m/s2 . Calculate the applied force. If the same force is applied on an object of mass 24 kg, how much will be the acceleration?
Given:
- Mass of the object (m) = 16 kg
- Acceleration (a) = 3 m/s²

To Find:
1. Applied force (F) on the 16 kg object.
2. Acceleration on a 24 kg object with the same force.

Formulas:
1. $F = m \cdot a$
2. $a = m/F$ (for the 24 kg object)

Calculations:
1. **Applied Force:**
   $F = m \cdot a = 16kg \cdot 3m/s^2 = 48N$
2. **Acceleration for 24 kg object:**
   $a = m/F = 24kg/48N = 2m/s^2$

Answer:
1. Applied force = 48 N
2. Acceleration on 24 kg object = 2 m/s²

(6) A car is moving at a constant velocity of 20 m/s for 10 seconds. What is the acceleration of the car and it type?
Given:
- Initial velocity (u) = 20 m/s
- Final velocity (v) = 20 m/s (constant velocity)
- Time (t) = 10 s

To Find:
Acceleration (a)
Formula:
$a = \frac{(v-u)}{t}$
Calculation:
$a = \frac{(v-u)}{t}$
$= \frac{(20m/s - 20m/s)}{10s}$
$= \frac{(0m/s)}{10s} = 0\ m/s^2$
Answer:
Acceleration = 0 m/s²
As a = 0, the acceleration is zero acceleration

(7) A bike starts from rest and reaches a velocity of 15 m/s in 5 seconds. What is the acceleration?
Given:
- Initial velocity (u) = 0 m/s (starts from rest)

- Final velocity (v) = 15 m/s
- Time (t) = 5 s

To Find:
Acceleration (a)
Formula:
a = $\frac{(v-u)}{t}$
Calculation:
a = $\frac{(v-u)}{t}$
= $\frac{(15m/s-0m/s)}{5s}$
= $\frac{(15m/s)}{5s}$ = 3 m/s²
Answer:
Acceleration = 3 m/s²
As a > 0, the acceleration is positive acceleration

(8) A car traveling at 25 m/s slows down to 5 m/s in 4 seconds. What is the acceleration?
Given:
- Initial velocity (u) = 25 m/s
- Final velocity (v) = 5 m/s
- Time (t) = 4 s

To Find:
Acceleration (a)
Formula:
a = $\frac{(v-u)}{t}$
Calculation:
a = $\frac{(v-u)}{t}$
= $\frac{(5m/s-25m/s)}{4s}$
= $\frac{(-20m/s)}{4s}$ = -5 m/s²
Answer:
Acceleration = -5 m/s²
As a < 0, the acceleration is negative acceleration.

(9) An aeroplane taxies on the runway for 30 s with an acceleration of 3.2 m/s2 before taking off. How much distance would it have covered on the runway?
Given:
- Time (t) = 30 s
- Acceleration (a) = 3.2 m/s²
- Initial velocity (u) = 0 m/s (starts from rest)

To Find:
Distance covered (s)
Formula:
Using the equation of motion:
$s=ut+\frac{1}{2}at^2$
Calculation:
Since the aeroplane starts from rest, u=0:
$s=ut+\frac{1}{2}at^2$
$s=0\cdot30+\frac{1}{2}\cdot3.2\cdot(30)^2$
$=\frac{1}{2}\cdot3.2\cdot900$
$=1.6\cdot900$
$=1440$ m

Answer:
Distance covered = 1440 m

(10) A kangaroo can jump 2.5 m vertically. What must be the initial velocity of the kangaroo?
Given:

- Maximum height (h) = 2.5 m
- Acceleration due to gravity (g) = 9.81 m/s² (acting downwards)

To Find:
Initial velocity (u) of the kangaroo
Formula:
Using the equation of motion:
$v^2=u^2+2gh$
At the peak of the jump, the final velocity (v) = 0 m/s.
$0=u^2-2gh$
So,
$u^2=2gh$
Calculation:
$u^2=2\cdot9.81\cdot2.5$
$=49.05$
$u=\sqrt{49.05} \approx 7$ m/s
Answer:
Initial velocity = 7 m/s

(11) A motorboat starts from rest and moves with uniform acceleration. If it attains the velocity of 15 m/s in 5 s, calculate the acceleration and the distance travelled in that time.
Given:

- Initial velocity (u) = 0 m/s (starts from rest)
- Final velocity (v) = 15 m/s
- Time (t) = 5 s

To Find:

1. Acceleration (a)
2. Distance travelled (s)

Formulas:

1. $a=\frac{v-u}{t}$
2. $s=ut+\frac{1}{2}at^2$

Calculations:

1. **Acceleration:**
   $a=\frac{v-u}{t}$
   $= \frac{15m/s-0m/s}{5s}$
   $= \frac{15m/s}{5s} = 3m/s^2$
2. **Distance travelled:**
   Using the distance formula:
   $s=ut+\frac{1}{2}at^2$
   $s=0\cdot5+\frac{1}{2}\cdot3\cdot(5)^2$
   $s=\frac{1}{2}\cdot3\cdot25$
   $s = 1.5\cdot25 = 37.5$ m

Answer:

1. Acceleration = 3 m/s²
2. Distance travelled = 37.5 m

(12) A cyclist covers a distance of 120 kilometers in 4 hours. What is the speed of the cyclist?
Given:

- Distance (d) = 120 km
- Time (t) = 4 hours

To Find:
Speed of the cyclist
Formula:
Speed = Distance / Time
Calculation:
Speed = (120 km/4 hours)=30 km/h
Answer:
Speed of the cyclist = 30 km/h

(13) A person walks 50 meters east, then 30 meters west, in 20 seconds. What is their average velocity?
Given:
- Distance east = 50 m
- Distance west = 30 m
- Time (t) = 20 s

To Find:
Average velocity
Formula:
Average velocity = Total displacement / Total time
Calculation:
Total displacement = 50 m - 30 m = 20 m (towards east)
Average velocity = (20 m/20 s)=1 m/s (towards east)
Answer:
Average velocity = 1 m/s east

(14) The mass of a cannon is 500 kg and it recoils with a speed of 0.25 m/s. What is the momentum of the cannon?
Given:
- Mass of the cannon (m) = 500 kg
- Recoil speed (v) = 0.25 m/s

To Find:
Momentum of the cannon
Formula:
Momentum (p) = Mass × Velocity
Calculation:
p = m·v
p = 500 kg·0.25 m/s
p = 125 kg·m/s
Answer:
Momentum of the cannon = 125 kg·m/s