In this chapter, we will basically dealing with Cause of Motion ⇒ Force

• Δ → Delta (sign)

FORCE

• It is defined as push or pull which tries to change or changes the state of rest or motion of body.

Effects of Force:-

• The force acting on a body, can do 3 things:-

(i) A force or a set of forces can change speed of body.

(ii) It can change dir (direction) of motion.

(iii) It can change shape of body.

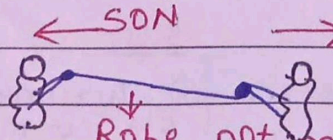
Types of Forces:-

Forces

Balanced Forces

• It will cause no change in speed of object.

e.g.-

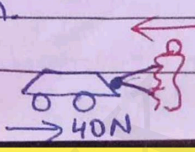


Unbalanced Forces

• These forces are not equal.

• It always cause the motion.

e.g.-



• Man will push car.

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★ NEWTONS LAWS OF MOTION

(A) FIRST LAW

- It states that a body continues to be in state of rest or of uniform velocity until and unless an external unbalanced forces is acted on body.

Eg → (i) A ball will keep on ground. It neither goal nor move until & unless we apply a kick on it.

Note → (i) Each and every body has a tendency to resist its change in state of motion. This property of body is called *Inertia.

(ii) Inertia of a body is directly proportional to mass.

(iii) Newton's first law is also known as law of Inertia.

▶ **Types of Inertia** :- There are three types.

i.) Inertia of Rest :-	ii.) Inertia of motion	iii.) Inertia of direction
⊙ Tendency of a body to continue in state of rest even when some unbalanced force is applied on it.	⊙ The tendency of the body to continue in its state of motion even some unbalanced forces apply on it.	⊙ The tendency of a body to oppose any change in its direction of motion
Eg-	Eg-	Eg-
⊙ A boy filled with water.	⊙ A Running person	⊙ Turning bicycle on corner of road

LINEAR MOMENTUM ($\vec{p}$)

- It is defined as product of mass and velocity.
- It is power of motion of an object.
- It is a vector quantity.
  - Magnitude
    - $|\vec{p}| = mv$
      - v → velocity of object.
      - p → Momentum
      - m → mass of object
  - Direction
    - It along's the dirn of velocity

- Unit of momentum :- Kg m/s.
- **Feel of momentum** :⇒
  If we drop two bodies, one light and one heavy, from the top of a tower simultaneously.
  ⇒ Obviously, it is easier to catch the lighter one than the heavier one. However, both of them have same velocity at bottom.

 # Force :- It is defined as product of Mass and acceleration.

- It is a vector quantity.
- Direction is along direction of acceleration
- SI unit :- Kg m/s^2 or Newton (N).
- CGS unit :- Dyne ($1N = 10^5$ dyne)

2) SECOND LAW :⇒

- The rate of change of momentum of a body is directly propotional to the applied unbalanced forces.

Eg ★ Rate of change of momentum ∝ Force applied

- Derivation of first law from second law :-

⇒ • Initial momentum ⇒ $p_1 = mv_1$
• final momentum ⇒ $p_2 = mv_2$

• change :- $\Delta p = m(v_2 - v_1) = p_2 - p_1$

Acc. to law,

• Rate of change of momentum $= \frac{\Delta p}{\Delta t} = \frac{m(v_2 - v_1)}{t}$ — (I)

• From Eqn of motion,
$v = u + at$; $a = \frac{v-u}{t}$ — (II)

By law, $F \propto \frac{\Delta p}{\Delta t}$, $\Rightarrow a$ {∵ using (I) & (II)}

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

$F \propto ma \Rightarrow$ ★ $\boxed{F = kma}$

↓ • proportionality constant ($k = 1$).

★ • Jab bhi proportionality hatti hai to kuch constant lagta hai.

• From Ist law, $u = v$ then

★ $\boxed{\vec{F} = 0}$

• This law is also called, universal law.

Q. Define one Newton?

⇒ $F = ma$ $(m=1 ; a=1)$

- when force applied on body of 1Kg produces acc of $1 m/s^2$.

★ IMPULSE

- The product of the magnitude of a force applied on a body and the time for which it is applied.

Mathematically. $I = F\Delta t$

SI unit :- (N-S)

Eg-

(i) catching the ball by a cricketer,

(ii) Jumping on a heap of sand.

E.) Newton's third law

- To Every action there is an equal and opposite reaction.

- Action- reaction pair does not react on same body.

Eg-

(i) swimmer pushes the water with his hands and feet to move in forward dir of flow

(ii) A gun recoil.
(iii) Rowing a boat.

★ Law of conservation of momentum :-

- When two or more bodies acts upon one another, their total momentum remains constant (or conserved) provided no external force acting.

OR

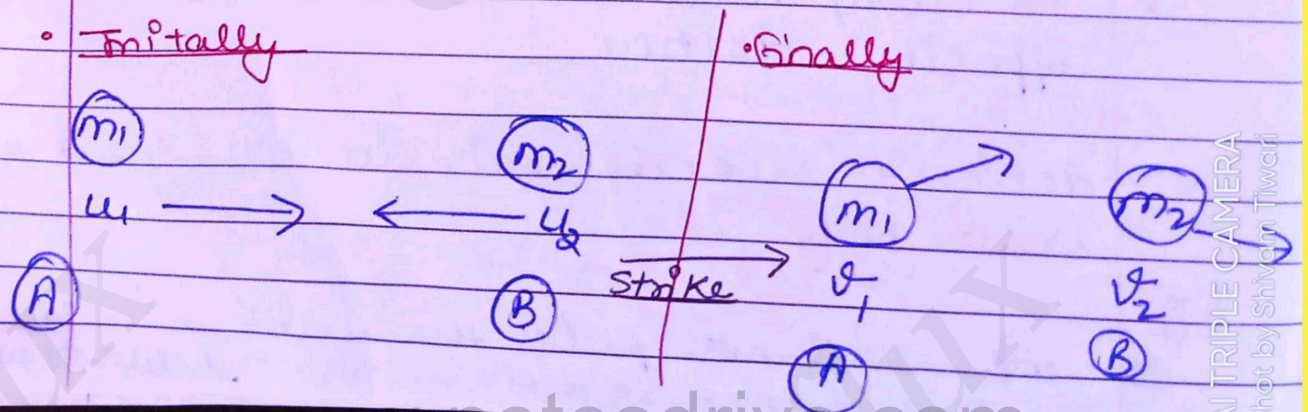
- If an external force acting on the body is zero, the total momentum of system remains constant.

Thus,

★ Initial momentum = final momentum
$P_i = P_f$

- Derivation,

Suppose two objects A & B each of mass m_1 & m_2 are moving initially with velocity u_1 & u_2 strike each other after time t & start moving with velocities v_1 & v_2 respectively.



- Initial momentum of object A = m_1u_1
- " " " " B = m_2u_2
- " " " " C = m_1v_1
- " " " " D = m_2v_2

- Rate of change of momentum in A,

$$F = \frac{m_1v_1 - m_2u_1}{t}$$

$$\boxed{F = \frac{m_1(v_1 - u_1)}{t}}$$

- Rate of change of momentum in B,

$$F = \frac{m_2v_2 - m_2u_2}{t}$$

$$= \frac{m_2(v_2 - u_2)}{t}$$

$$\boxed{F = \frac{m_2(v_2 - u_2)}{t}}$$

- We know that from (III) law of motion

$$\boxed{F_1 = -F_2}$$

$$\frac{m_1(v_1 - u_1)}{t} = -\left(\frac{m_2(v_2 - u_2)}{t}\right)$$

$$m_1v_1 - m_1u_1 = -m_2v_2 + m_2u_2$$

$$\boxed{m_1v_1 + m_2v_2 = m_1u_1 + m_2u_2}$$

- $P_f = P_i$
- Final momentum = Initial momentum

Example 3. *A car having mass of 1000 kg is moving with a velocity of 0.5 m/s. What will be its momentum ?*

Solution : Given, Velocity of the car (v) = 0.5 m/s

Mass of the car (m) = 1000 kg

Momentum (p) = ?

We know that, Momentum (p) = Mass (m) × Velocity (v)

Therefore, p = 1000 kg × 0.5 m/s = 500 kg m/s

Thus, momentum of the car = 500 kg m/s. **Ans.**

Example 1. *A bullet of mass 20 g is fired horizontally with a velocity of 150 m/s from a pistol of mass 2 kg. Find the recoil velocity of the pistol.*

Solution : Given, Mass (m_1) of bullet = 20 g = 0.02 kg

Mass (m_2) of pistol = 2 kg

Initially bullet is inside the gun and it is not moving.

So, Mass $= m_1 + m_2 = (0.02 + 2)$ kg $= 2.02$ kg

And $u_1 = 0$

So, Initial momentum $= 2.02 \times 0 = 0$ ...(i)

Finally let the velocity of pistol be v_2 and v_1 for bullet = 150

So, Final momentum $= m_1 v_1 + m_2 v_2$

$= 0.02 \times 150 + 2v_2$ ...(ii)

We know that Initial momentum = Final momentum

So, $0 = \frac{0.02 \times 150}{100} + 2v_2$ [From equations (i) and (ii)]

$\Rightarrow$ $3 + 2v_2 = 0$

Or $2v_2 = -3$

Or $v_2 = -1.5$ m/s **Ans.**

(–)ve sign indicates that gun recoils in direction opposite to that of the bullet.

Example 2. *Two hockey players viz A of mass 50 kg is moving with a velocity of 4 m/s and another one B belonging to opposite team with mass 60 kg is moving with 3 m/s, get entangled while chasing and fall down. Find the velocity with which they fall down and in which direction ?*

Solution : Given, $m_A = 50$ kg, $u_A = 4$ m/s

$m_B = 60$ kg, $u_B = 3$ m/s

Initial momentum$_A$ $= m_A u_A$

$= 50 \times 4 = 200$ kg m/s

Initial momentum$_B$ $= m_B u_B$

$= 60 \times 3 = 180$ kg m/s

So, Total initial momentum $= 200 + 180 = 380$ kg m/s ...(i)

Final momentum $= (m_A + m_B)v = (50 + 60)v$

$= 110v$ ...(ii)

According to the law of conservation of momentum,

$380 = 110v$

Or $v = \frac{380}{110} = 3.454$ m/s **Ans.**

QUESTIONS

VERY SHORT ANSWER TYPE QUESTIONS

1. Can force be (–)ve ? When ?
2. What is the tendency of a body to resist its change of state called ?
3. Inertia is also measured by.....of an object.
4. Higher the mass of an object, higher is its..... .
5. $\frac{\text{Force}}{\text{Acceleration}}$ is determined by.....which is also mass of the object.
6. Why does the load from the cage above the seats in a bus falls down when suddenly brakes are applied ?
7. When a tree is shaken, its fruits and leaves fall down. Why?
8. Define Momentum of a body.
9. On what factors does the momentum of a body depend?
10. Why it is difficult to walk on a slippery road?

SHORT ANSWER TYPE QUESTIONS

1. Quantity of motion contained in a body is..... .
2. Unit of momentum is..... .
3. Define 1 Newton.
4. Although we know that a moving body keeps moving indefinitely until an external force is applied on it, then why does a ball stops when we slide it on ground (without stopping it) ?
5. Why is it difficult to stop a truck suddenly than a motorbike ?
6. When a metro suddenly stops all the passengers fell forward on its floor. Why do this happen ?

7. We have a huge atmosphere above us that exerts a huge pressure on our shoulders, head and whole body. Why don't we get crushed under it ?

8. A coin of mass 1 kg and a stone of mass 5 kg are thrown down the Eiffel Tower with an acceleration of 10 m/s^2. Which one would reach the ground early and why ?

9. Give applications of Ist law of motion i.e., inertia.

10. (a) Friction is measured in..... .

(b) Distinguish between balanced and unbalance forces.

LONG ANSWER TYPE QUESTIONS

1. (a) Derive first law of Newton from second law.

(b) Find the force required to stop a car of mass 100 kg with two passengers each of 50 kg sitting inside, if it is moving at 60 km/hr speed and takes 5 s to stop.

2. Two balls A and B of masses 40 g and 50 g are moving at speeds of 40 m/s and 30 m/s respectively. If after colliding, B stars moving with a velocity of 25 m/s, what is the velocity of A ?

3. A girl of mass 30 kg jumps on a cart of mass 5 kg with a velocity of 10 m/s. Find the velocity with which she and cart start moving after she jumps on it.

4. (a) Why does a gunman get a jerk on firing a bullet?

(b) Calculate the momentum of a toy car of mass 200 gm moving with a speed of 5 m/s. [Hint - convert mass into kg].

(c) State the law of conservation of momentum.

5. For how long should a force of 100 N acts on a body of 20 kg so that it acquires a velocity of 100 ms? [Hint - using formula f = ma. V = u + at]

6. (a) Find the acceleration produced by a force of 5 N acting on a mass of 10 kg.

(b) Which would require a greater force : (a) accelerating a 10 gm mass of 5 m/s^2 or (b) a 20 gm mass at 2 m/s^2? [convert mass into kg].

7. The velocity of a body of mass 10 kg increases from 4 m/s to 8 m/s when a force acts on it for 2s.

(a) What is the momentum before the force acts?

(b) What is the momentum after the force acts?

(c) What is the gain in momentum per second?

(d) What is the value of force?

$$\left[\text{Hint} - a = \frac{v-u}{t} \text{ and } f = ma\right]$$

Answers to Long Answer Type Questions

1. (b) - 2000/3 N
2. 46.25 m/s
3. 8.57 m/s
4. (b) 1 kg/ms
5. 20 sec.
6. (a) 0.5 m/s^2
   (b) A greater force of 0.05 N is required for accelerating a 10 gm mass.
7. (a) 40 kg.m/s
   (b) 80 kg.m/s
   (c) 20 $kg.m/s^2$
   (d) 20 N.

OBJECTIVE TYPE QUESTIONS :

MCQ.

1. **A truck and a car are moving with equal velocity, on applying braes, both will stop after certain distance and then :**

   (a) Truck will cover less distance before stopping.

   (b) Car will cover less distance before stopping.

   (c) Both will cover equal distance.

   (d) None of the above.

2. **In which of the following cases, the net force is not zero ?**

   (a) An object floating in air

   (b) A ball freely falling from a certain height.

   (c) A cork floating on the surface of water

   (d) All the cases.

3. **A force acts on a body of mass 3kg such that its velocity changes from $4ms^{-1}$ to $10\ ms^{-1}$. The change in momentum of the body is :**

   (a) $42Kgms^{-1}$ (b) $2Kgms^{-1}$ (c) $18Kgms^{-1}$ (d) $14Kgms^{-1}$

4. **While opening a top with two fingers, the force applied are:**

   (a) equal in magnitude (b) Paralled to each other

   (c) opposite in direction (d) All of the above

5. **The engine of a car produces an acceleration of $4ms^{-2}$ in a car, if this Car pulls another car of same mass, what is the acceleration produces ?**

(a) $8ms^{-2}$ (b) $2ms^{-2}$ (c) $4ms^{-2}$ (d) $0.5ms^{-2}$

6. **A force 100N acts in a body mass 2kg for 10 sec. The change in the velocity of the body is.**

(a) $100ms^{-1}$ (b) $250ms^{-1}$ (c) $500ms^{-1}$ (d) $1000ms^{-1}$

Assertion and Reason type questions :

Choose the appropriate answer :

(a) If both assertion and reason are CORRECT and reason is the CORRECT explanation of the assertion.

(b) If both assertion and reason are CORRECT but reason is. NOT THE CORRECT explanation of the assertions.

(c) If assertion is CORRECT but reason is INCORRECT

(d) If assertions is INCORRECT but reason is CORRECT

(e) If both assertions and reason are INCORRECT

1. **Assestion :** If the not external force on the body is Zero, then its accelerations is Zero.

Reason : Acceleration does not depend on force.

A. (a) b. (b) c (c) d (d) d (e) e

2. **Assertion :** If two objects of different masses have same momentum, the lighter body posses greater velocity.

Reason : For all bodies momentum always remains same.

A. (a) b (b) c (c) d (d) d (e) e

3. **Assertion :** Newton's third law of motion is applicable only when bodies are in motion.

Reason : Newton's third law applies to all types of forces eg.: gravitaional, electric or magnetic force etc.

A. (a) b. (b) c (c) d (d) d (e) e

CONCEPT MAPPING