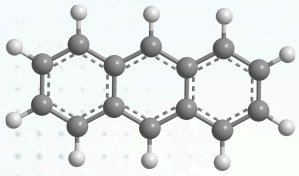
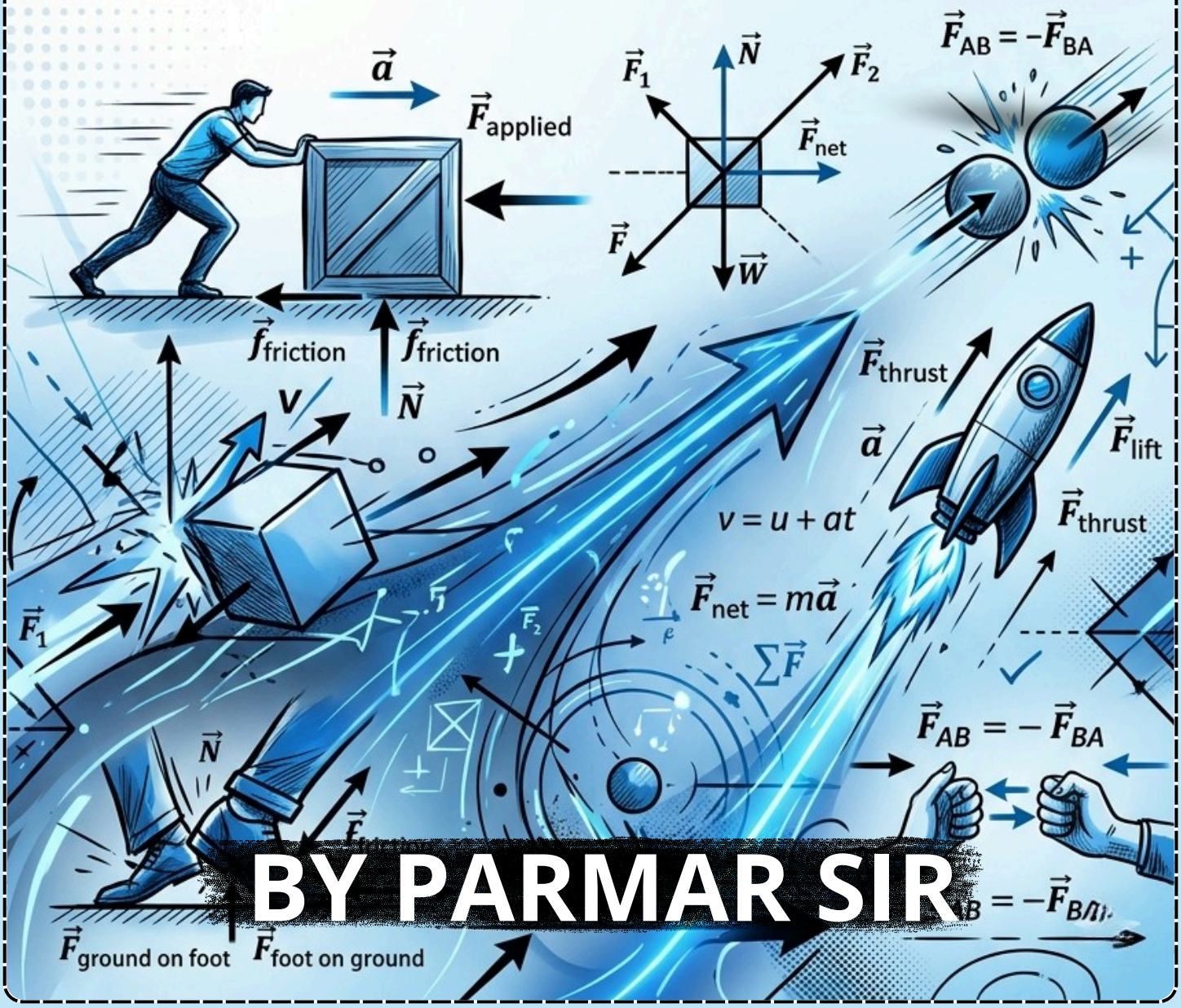
PARMAR SSC

FORCE AND LAWS OF MOTION



Lecture - 2



BY PARMAR SIR

Force

- Force is an external agent capable of changing a body's state of rest or motion. The SI unit of force is Newton (N), A newton is defined as **1 kg m/s²**.



The Force has different effects, and here are some of them

1. MAKE A RESTING OBJECT MOVE



Force can make a body that is at rest to move.

2. STOPS OR SLOWS DOWN MOTION



It can stop a moving body or slow it down.

3. ACCELERATES A MOVING BODY



It can accelerate the speed of a moving body.

4. CHANGES DIRECTION, SHAPE & SIZE



It can also change the direction of moving body along with its shape and size.

Balanced Forces

- Balanced forces are forces that cancel each other out because they are equal in strength and act in opposite directions.
- The net force acting on an object when forces are balanced is zero (Fnet = 0).



When the man pushes against the wall, the forces at play balance each other, and as a result, the wall does not move.

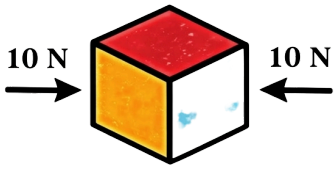
Unbalanced Forces

- Unbalanced forces are forces that are not equal in magnitude and/or act in the same direction.
- The net force acting on an object when forces are unbalanced is not zero (Fnet ≠ 0).

One person significantly heavier than the other creates a condition of unbalanced forces in a seesaw.



Case 1



Balanced Force
Net Force = 0 N
Acceleration = 0

Case 2



Net Force = 10 N (Left)
Unbalanced Force

Types of Forces

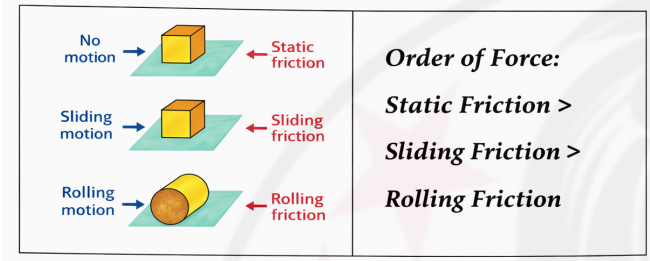
Contact Forces

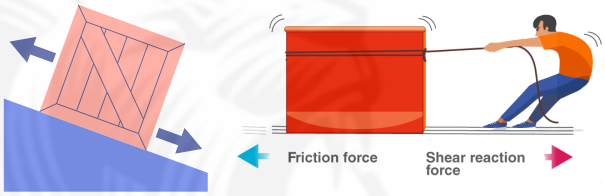
- A contact force is a force that acts on a body either directly or through a medium are called contact forces.

Types of Contact Forces

Frictional Force

- Frictional Force refers to the force generated by two surfaces that contact and slide against each other.



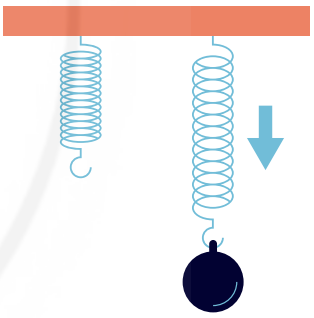


Spring Force

- The spring force is a restoring forced exerted by a spring when it is stretched or compressed.

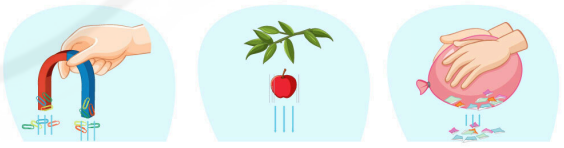
Hooke's Law

It states that the force needed to extend or compress a spring (or any elastic material) by a certain distance is directly proportional to that distance.



Non-Contact Forces

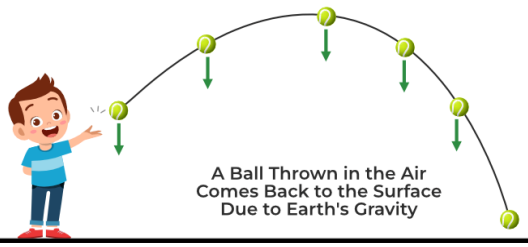
- A non-contact force is a force applied to by another body that is not in direct contact with it.

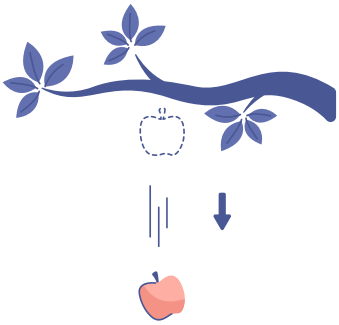


Types of Non-Contact Forces

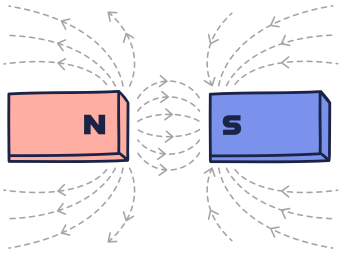
Gravitational Force

- A gravitational force is an attractive force between two masses.



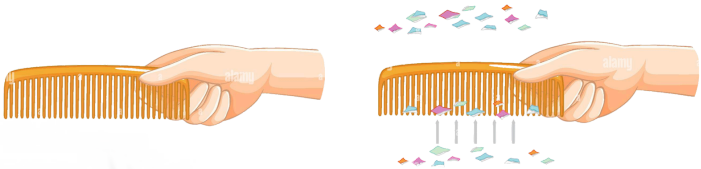


Magnetic Force



- Magnetic force is the force experienced by a moving electric charge / magnetic material in a magnetic field. It can also refer to the attractive or repulsive interaction between magnetic materials or magnets.

Electrostatic Force



- The electrostatic force, also known as the Coulomb force, is the attractive or repulsive force between two electrically charged objects.

Conservative Forces	Non-Conservative Forces
Work done is independent of the path (depends on final and initial point)	Work done depends upon the path
Work done is zero in case of a closed path	Work done is not zero in case of a closed path
Work done by it is completely recoverable	Work done is not completely recoverable; some energy is lost (usually as heat)
Examples: Gravitational, electrostatic, magnetic, spring force	**Examples**: Frictional force, Drag

LAWS OF MOTION

- Galileo Galilei first proposed the concept of inertia. By observing the motion of objects on an inclined plane Galileo deduced that objects moving with a constant speed when no forces act on them.
- **Galileo published a series of essays named:** De Motu (Meaning: "On Motion")
- **Galileo's first book:** La Bilancetta ("The Little Balance") published in 1586.
- Newton formulated the three laws of motion.

1st Law of Motion → Law of Inertia

- The Law of Inertia states that "An object at rest remains at rest and an object in motion remains in motion at constant velocity unless acted upon by an external force".



An Object that is at Rest will stay at Rest Untill an External Force acts upon it

Types of Inertia

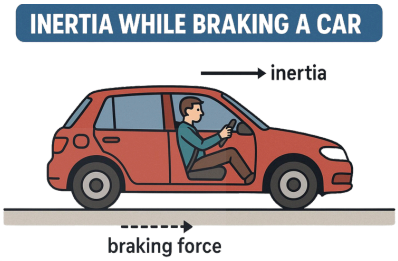


1. Inertia of Rest: This is the tendency of an object to remain at rest unless acted upon by an external force.

E.g. The dry leaves and fruits falls when we shake a tree.

2. Inertia of Motion: This is the tendency of an object to continue moving in a straight line at a constant speed unless acted upon by an external force.

E.g. A person sitting in a moving car may be pushed forward when the car stops abruptly as our legs are in contact with the surface.



3. Inertia of Direction: This is the tendency of an object to continue moving in the same direction unless acted upon by an external force.

E.g. When a car makes a sharp turn, your body tends to move in the direction it was previously moving, rather than following the car's new direction.



The tendency of an object to resist changes in its state of motion. It depends on the mass of the object.

INERTIA ∝ MASS

2nd Law of Motion

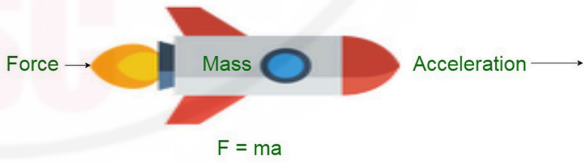
- The 2nd Law of Motion states that force equals mass times acceleration, or F = ma. This law describes how the acceleration of an object depends on the force applied to it and the object's mass.
- **E.g.** A cricketer pulling back his hand while catching the ball to avoid injury.

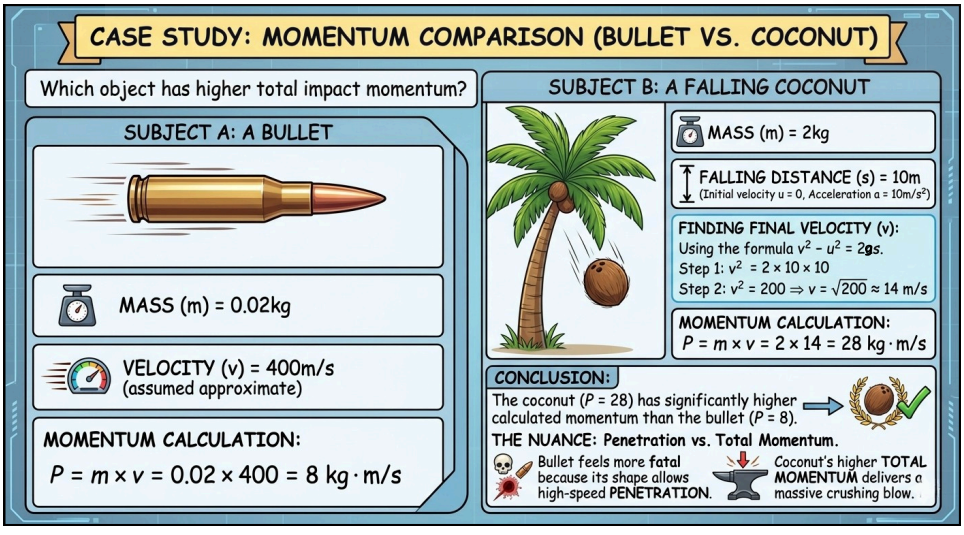


Force ∝ Rate of change of momentum

F = ma

F = Kg m/s²





DERIVATION

Derivation:

Change in momentum $= mV - mu$

Rate of change in momentum with time $= \frac{mV - mu}{t}$

We know $\frac{V-u}{t} = a$ *(acceleration);*

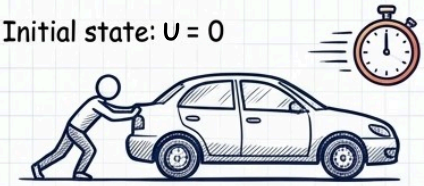
$$\left(\frac{mV-u}{t} = ma\right)$$

RELATING FORCE TO "RATE OF CHANGE OF MOMENTUM"

Demonstrated using the example of pushing a car (Mass m = 1000kg).

Scenario 1: One Person Pushing

Initial state: U = 0



$P_i = 1000 \times 0 = 0$ kg·m/s

One person pushes for 10 seconds (t = 10s) to reach velocity v = 2 m/s.



$P_f = 1000 \times 2 = 2000$ kg·m/s

Change in Momentum (ΔP) = 2000 – 0 = 2000 kg·m/s

Rate of Change of P = $\frac{\Delta P}{\text{time}} = \frac{2000}{10} = 200$ N (Force)

Scenario 2: Two People Pushing (Doubling the Force)

Now the velocity is further changed from 2m/s to 4m/s.



Initial state: $P_i = 2000$ kg·m/s

Two people apply force for 5 seconds (t = 5s) to reach v = 4 m/s.



$P_{fnew} = 1000 \times 4 = 4000$ kg·m/s

Change in Momentum (ΔP_{new}) = 4000 – 2000 = 2000 kg·m/s

Rate of Change of P = $\frac{\Delta P_{new}}{\text{time}} = \frac{2000}{5} = 400$ N (Force)

Conclusion and Derivation

COMPARISON AND CONCLUSION

Comparing Scenario 1 & 2:

200N vs 400N

Doubling the force (Scenario 2) doubled the rate of change of momentum (from 200N to 400N).

This confirms:
Force is proportional to the Rate of Change of Momentum.

DERIVATION OF THE MAIN FORMULA (F = ma)

$F \propto \frac{\text{Change in Momentum } (\Delta P)}{\text{Time } (\Delta t)}$

Since $\Delta P = m \cdot \Delta v$ (change in velocity)

$F \propto m \cdot \frac{\Delta v}{\Delta t}$

Using $a = \frac{\Delta v}{\Delta t}$ (Definition of Acceleration)

F = ma
(Force = Mass x Acceleration)

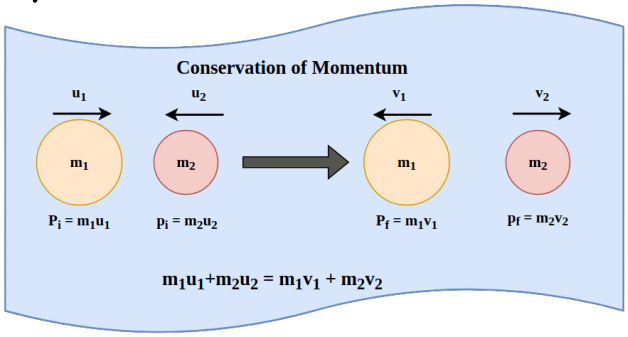
3rd Law of Motion



- The 3rd Law of Motion states that "For every action, there is an equal and opposite reaction" meaning if one object exerts a force on another, the second object will exert an equal and opposite force back on the first.
- **E.g.** When a gun fires, the bullet experiences a forward force, and the gun experiences an equal and opposite force, causing it to recoil backward.

Conservation of Momentum

The conservation of momentum principle states that "In a closed system, the total momentum remains constant", meaning momentum is neither created nor destroyed, but only transferred.



In the equation, m_1 and m_2 are masses of the bodies, u_1 and u_2 are the initial velocities of the body and v_1 and v_2 are the final velocities of the bodies (change in velocity not mass).

Impulse and Momentum

Momentum measures the "quantity of motion" of an object, defined as the product of its mass and velocity.

The S.I. unit of Momentum is Kg m/s.

$p = m \times v$

p = vector quantity
m = scalar quantity
v = vector quantity

Conservation of Momentum

Impulse is the change in momentum of an object caused by a force acting over a short period of time.

Impulse-Momentum Theorem: $F \Delta t = m \Delta V$

p = vector quantity
m = scalar quantity
v = vector quantity



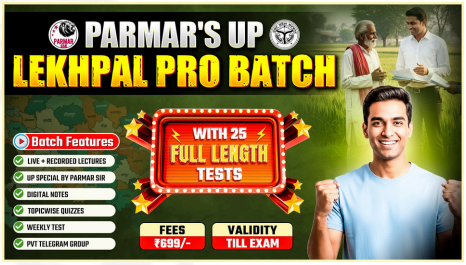
Join Now – Start Your Smart Preparation Today!

CLICK HERE



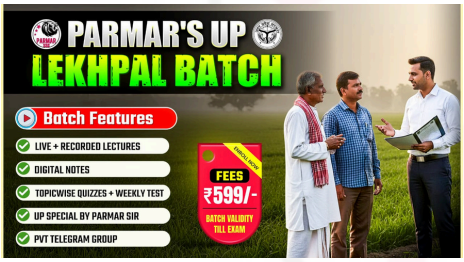
Join Now – Start Your Smart Preparation Today!

CLICK HERE



Join Now – Start Your Smart Preparation Today!

CLICK HERE



Join Now – Start Your Smart Preparation Today!

CLICK HERE



Join Now – Start Your Smart Preparation Today!

CLICK HERE





Now Listen Parmar ssc classes on SPOTIFY CLICK HERE