FORCE and Newton's Laws

2.1 Forces and Their Effects

A **force** is a push or a pull. It can cause an object at rest to be in motion, or a body in motion to change its speed or direction. It can change the shape and size of an object. It has both size and direction.

Types of forces:

1) **Friction:** A force that opposes the motion of two surfaces in Contact. The force acts in the opposite direction of motion.

2) **Gravity:** This is a force that attracts objects towards the center of the Earth. E.g. Gravity keeps us on land.

3) **Centripetal force:** This is a force that keeps an object moving in a circular path. For example, the force of gravity keeps the satellite in orbit and the centripetal force keeps it moving around the Earth. For any circular motion to occur, inward perpendicular force must act upon the object.

4) **Elastic force:** A force in elastic material when stretched or compressed. E.g. Stretching a rubber band.

5) **Buoyant force:** It is an upward force exerted by a fluid on an Object immersed in it. E.g. A boat experiences a buoyant force.

6) **Magnetic force:** A force that attracts or repels objects with magnetic properties. E.g. Two magnets with unlike poles attract.

7) **Electrostatic force:** A force that attracts or repels objects that are charged. E.g. Rubbing a rule on hair and attracting small pieces of paper.

8) **Drag:** A force acting in the opposing direction off an object moving through a fluid.

9.) **Air resistance**: A force acting In the opposing direction on an object moving through air.

10) **Thrust force**: This is the force that pushes or propels an object forward. Eg, Thrust force is used to propel the rocket upward into the sky.

11) **Nuclear force**: These are forces that hold the proters and neutrons together within an atomic nucleus.

12) **Centrifugal force**: Is a force acting radially outward on a rotating Object to move it outward. E.g. the feeling of being pushed outward in a Spinning amusement park ride.

13) **Tension**: A pulling force that occurs in the string or rope when a force is applied to each element. Eg A rope supporting a hanging object.

14) **Torsional forces**: It is a force used in twisting or rotating objects. E.g. Twisting 2 ends of a wet cloth to drench water out of it.

2.2 Newton's Laws

Newton's First LAW

Isaac Newton's First Law of Motion
LAW OF INERTIA

→ An object at rest will remain at rest unless acted on by an unbalanced force. An object in motion continues with the same speed in the same direction unless acted upon by an unbalanced force.

or

→ An object stays at rest or continues to move in a straight line at constant speed unless acted on by a resultant force.

For example: A still ball will not move me or be in motion until someone applies force by Kicking it.

The ball will move in a straight line but eventually stop due to forces like gravity and friction will cause it to stop moving.

While the ball is rolling, it is rubbing against the grass and friction slows the ball down little by little and the force of gravity is pulling the ball downward. When the ball is still, all forces acting upon it are equal.

Galileo created the concept of Inertia while Newton confirmed this idea in 1687.

NEWTON'S SECOND LAW

Isaac Newton's Second Law of Motion

→The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass This means that if You apply force to an object, It will accelerate in the direction of that force The greater the force applied, the greater the acceleration, and the greater the mass, the less the acceleration for the same force.

$$\vec{F} = m\,\vec{a}$$

a is the acceleration of the object
F is the net (resultant) force
m is the mass of the object

or

→Acceleration is produced when a force acts on mass. The greater the mass of the object being accelerated, the greater the amount of force needed to accelerate the object.

Note: The vector arrowheads mean that the force and the acceleration always have to be in the same direction.

- The mass tells us how much influence that force has to produce a change in motion.
- As long as the force is being applied the acceleration is happening.

NEWTON'S THIRD LAW

Isaac Newton's Third Law of Motion

→When two objects interact, the forces they exert on each other are equal and opposite.

or

→For every action, there is an equal and opposite reaction.

For example: A swimmer pushes against the pool wall with her feet and accelerates in the direction opposite to that of her Push. The wall has exerted an equal and opposite force back on the swimmer.

- The forces are equal in magnitude or size but opposite in direction.

- Whenever a force acts, then there is another force acting back again that is equal in size and Opposite in direction.

2.3 Gravitational Force

Weight is a force of gravity acting on an object with mass.
Weight = mass x acceleration due to gravity
W = m g

Acceleration due to gravity (g): Gravitational force causes objects to accelerate towards the center of Earth. It is approximately 9.8m/s².

The gravitational constant (G) is a fundamental constant in physics. It is approximately equal to

$6.674 \times 10^{-11}\ Nm^2/kg^2$

→ It is used to determine the Strength of the gravitational force.

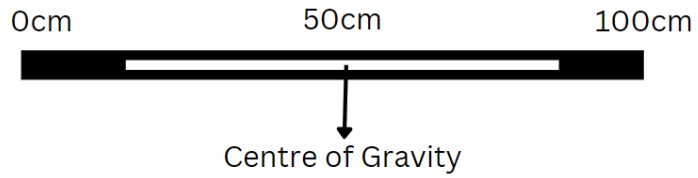
- The Larger the mass of an object, the stronger the gravitational pull.

Gravitational force is the cause of the Orbital motion of celestial bodies such as the gravitational force of the sun keeps the planets In orbit.

CENTER OF GRAVITY

The Centre of Gravity is the point through which all of an object's weight can be considered to act.

For example:



This is a 100cm ruler. Its Centre of Gravity is at the point where the symmetrical lines meet.

How to find the center of gravity of an irregularly shaped Lamina:

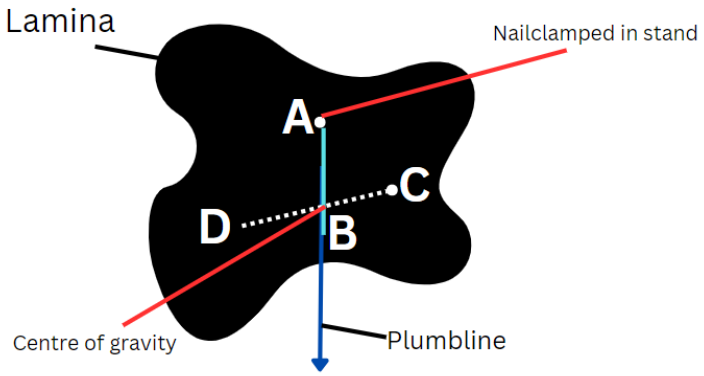
Lamina: Thin sheet of cardboard.

1) Make a hole A in the Lamina and hang it on a nail clamp in a stand so that it can swing freely

2) Tie a plumbline to the nail and mark its position AB on the Lanina

3) Create another hole C and use that point to hold the lamina and mark the plumbline position CD

4) The Point AB intersects with the CD. That intersection point is the Centre of gravity



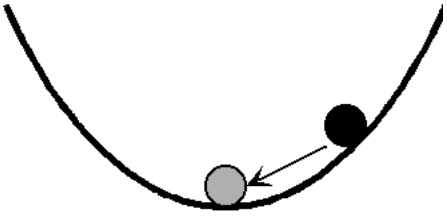
Plumbline: A thread tied with weight.

STABILITY

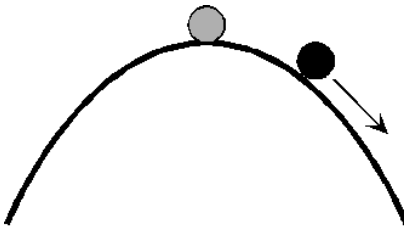
Stability is the ability of an object to maintain a balanced position / steady state.

There are three types of stability:

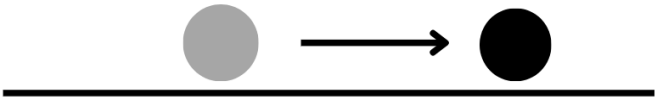
Stable stability: This is when an object is slightly displaced and will return to its original position. This is caused when its gravitational Potential energy increases as its Position moves away from the equilibrium The returns back object naturally to the equilibrium Position when it loses gravitational Potential energy.
The ball will roll up and down and will settle over time in the Position of its equilibrium.



Unstable Stability: This is when an object is displaced and will not naturally return to its original position and it will move away instead This happens because the gravitational Potential energy decreases as its position moves away from the equilibrium position. The object naturally moves away from the equilibrium position when it loses gravitational Potential energy.
The ball will be displaced in either of the directions and will not return to its original position.



Neutral stability: An object is in neutral equilibrium if it Stays in its new position when displaced. This is because when an object is in neutral equilibrium, the gravitational potential energy of the object remains constant regardless of its position.
The ball is displaced to its right and stays in its new Position



Factors that increase stability:

1) **Lowering its Centre of gravity:** This means bringing the mass of the object closer to the ground.

2) **Increasing the area of the base**: the object becomes more resistant to tipping over. It allows Providing more points of contact with the supporting surface.

For example: Racing cars have a low center of gravity and a wider base area to maximize Stability.

2.4 Frictional Force

Whenever an object is in motion along a surface, the surface exerts a force upon the object. This is called the **frictional force.**

- The Smoother a surface is, the Lesser the friction

Two main types of friction:

1) Static friction.

2) Kinetic friction. (Dynamic friction)

Static friction

This is the force that opposes the initiation of motion between two surfaces that are in Contact but none of the objects are in motion.
If you place a block on the table and try to push it very lightly, it will resist that motion because of the frictional force operating in the direction opposite the applied force of your Push

Static friction will increase until the applied force magnitude exceeds the maximum static frictional force and the object begins to accelerate

This frictional force is proportional to the normal force. The heavier the object, the greater the normal force and the greater the friction force This is because as the weight of the object increases, the harder the surface which it presses down will increase the number of contact points between the object and the Surface.

Kinetic Friction

Kinetic friction also known as dynamic friction refers to the force that opposes motion/movement of two surfaces that are in contact and sliding past each other. It comes into action when the object is in motion already

- It opposes the motion to slow or stop the motion of the object.

- The size of Kinetic friction depends on the material of the Surface in contact. Smoother surfaces resist Kinetic friction by a small amount while rough surfaces support Kinetic friction.

- The force of Kinetic friction is less than the force of static friction because it takes more! force to overcome static friction to initiate motion.
- Kinetic friction opposes the direction of motion.