MODULE 10

UNDERSTANDING INERTIA & NEWTON'S FIRST LAW

Inertia

So far, we are familiar with the idea of force as the physical reason behind changes in motion. We also understand that is the **resultant force** that matters, not individual forces acting alone.

We now take a crucial step forward by examining what happens **when the resultant force on a body is zero**. Surprisingly, this simple situation explains a large part of everyday motion and introduces one of the most fundamental ideas in physics: **inertia**.

To understand inertia, consider the following observations:

First observation: Consider a book resting on a table. It remains at rest unless someone pushes it.

Second observation: Consider the same book sliding smoothly on a polished surface. It continues moving unless something stops it.

These observations suggest a common idea: *Bodies resist changes in their state of motion.*

This resistance to change is what we call **inertia**. Inertia *is the tendency of a body to remain at rest if it is at rest, or continue moving with constant velocity if it is already in motion, unless acted upon by a* ***resultant force****.* It is not a force. It is a property of matter.

Mass as a Measure of Inertia

Not all bodies resist change in the same way. A light object is easy to start moving or stop. A heavy object is much harder to do so.

This tells us that inertia depends on the **mass** of the body. Therefore, we can conclude that:

- A body with large mass has large inertia.
- A body with small mass has small inertia.

So, *mass is a measure of inertia*.

This idea explains why the same force produces different accelerations on different bodies.

Newton's First Law of Motion

The ideas of inertia and resultant force are formally stated in **Newton's first law of motion** as follows:

A body remains at rest or continues to move with constant velocity in a straight line unless acted upon by a resultant force.

This law does **not** say that forces are absent. It says that **the resultant force is zero**. Therefore:

- zero resultant force implies that acceleration is zero,
- no acceleration implies that velocity remains constant (or zero).

Newton's first law is sometimes called the **law of inertia** because it describes how inertia governs motion when forces balance. The law is important because:

- It corrects the common belief that force is needed to maintain motion.
- It explains what happens when forces balance.
- It provides the reference case for all other force situations.

For now, take a short breath and set theory aside, let us warm up with some carefully chosen worked examples.

BINDER Example 4

A puck slides along a smooth horizontal surface with constant velocity. Explain what this motion tells you about the forces acting on the puck.

Solution

Constant velocity means zero acceleration. Zero acceleration means the resultant force on the puck is zero. This implies that any forces acting on the puck balance each other, so there is no unbalanced force causing a change in velocity.

Making Sense of the Answer: *If there were a forward or backward resultant force, the puck would speed up or slow down. Since its velocity remains constant, no such force exists.*

Think Like a Physicist: *Constant velocity always means zero resultant force.*

REAL Example 5

Kipanga is standing inside a bus that is moving with constant velocity along a straight road. Suddenly, the bus stops abruptly, and Kipanga is thrown forward. Explain this observation using inertia.

Solution

Before the bus stops, Kipanga and the bus are moving together with the same velocity. When the bus stops, an external force acts on the bus, but Kipanga's body tends to continue moving forward due to inertia. Since no immediate force stops his body at the same time, he is thrown forward.

Making Sense of the Answer: *Kipanga's body tries to keep its original motion even though the bus has stopped.*

Think Like a Physicist: *Inertia makes a body resist changes in velocity.*

HOT Example 6

A block rests on a horizontal surface. Several forces act on it, but the block remains at rest. What can you conclude about the resultant force acting on the block? Explain.

Solution

Resultant force acting on block is zero.

Explanation

Since the block remains at rest, its velocity is constant and equal to zero. Constant velocity means zero acceleration. According to Newton's first law, this implies that the resultant force acting on the block is zero. Therefore, the forces acting on the block must balance.

Making Sense of the Answer: *If the forces did not balance, the block would start moving in the direction of the unbalanced force*.

Think Like a Physicist: *Rest is simply constant velocity equal to zero.*

That brings our worked examples to a comfortable stop; the second law is already peeking around the corner, curious to be explored!