

## MODULE 3

# KINEMATICS QUANTITIES MASTERY

### INTRODUCTION

Before Physics begins asking *why* things move, it first asks a simpler question: ***What exactly is happening when something moves?***

This may sound obvious. After all, you see motion every day: a daladala rushing past, rain falling, a football flying across a field, or yourself running late for class (a very common physics experiment). Yet describing motion precisely turns out to be subtler than it looks.

For example, when someone says, “*I walked very far,*” a physicist immediately wonders:

- How far exactly?
- In which direction?
- How fast?
- Did the speed change?

Suddenly, a casual statement becomes a scientific investigation.

This is where **kinematic quantities** enter the scene. They are the fundamental tools used to describe motion clearly and accurately, without yet worrying about forces or causes. Just as a photographer captures an image before analysing it, kinematics captures motion before explaining it.

The main kinematic quantities you will meet first are:

- **Distance:** How much ground is covered.
- **Displacement:** Where you end up relative to where you started.

- **Speed:** How fast distance is covered.
- **Velocity:** How fast and in what direction position changes.

At first glance, some of these pairs seem almost identical. Many students initially think distance and displacement are the same, or that speed and velocity are interchangeable. Physics gently disagrees. These subtle distinctions are not academic stubbornness; they are essential for understanding motion correctly.

And do not worry, mastering these ideas does not require superhuman intelligence. It simply requires careful thinking, curiosity, and sometimes a willingness to laugh at your own first misunderstandings. Every physicist has had those moments.

In fact, once you grasp kinematic quantities properly, something interesting happens: everyday life starts looking slightly more scientific. You begin noticing motion more carefully; how vehicles accelerate, how objects fall, how direction changes matter. Physics quietly moves from textbook pages into real life.

So before we rush into formulas and calculations, let us slow down and build a clear picture of motion itself. Strong foundations here will make everything that follows in A-Level Physics much easier, more logical, and, yes, even enjoyable!

Let us begin.

## **DISTANCE AND DISPLACEMENT**

**Distance** answers the question: *How much ground did you cover in total?* It depends on the entire path taken and it ignores direction, so it is always a **scalar quantity** and can never be negative.

**Displacement** answers a deeper question: *Where is your final position relative to your starting point?* It depends only on the starting and ending points (not the path),

and it carries direction, so it is a **vector quantity**. Displacement can be **positive, negative, or zero**, depending on the direction chosen.

Because of this, two journeys can have the **same distance** but **different displacements**, or even have a **large distance** with **zero displacement** (when you return to your starting point). In short, *distance measures the length of the journey, while displacement measures the actual change in position.*

To truly understand and enjoy these ideas, let us serve them in the form of worked examples.

### **BINDER Example 3**

A student walks 60m east from the dormitory to the library, then 20m west to the water tap. Find:

- (a) Distance travelled
- (b) Displacement

### **Solution**

(a) Distance =  $60 + 20 = 80\text{m}$

(b) Displacement =  $60 - 20 = 40\text{m east}$

**Making Sense of the Answer:** *The student walked 80m, but ended only 40m east of the starting point.*

**Think Like a Physicist:** *Distance is always greater than or equal to the magnitude of displacement, because distance counts the whole path.*

### **REAL Example 4**

After school, **Kipanga** runs one complete lap around the circular football field and stops exactly where he started. Determine his:

(a) Distance travelled

(b) Displacement

### **Solution**

(a) Distance travelled = the **circumference** of the circular field (one complete lap).

(b) Displacement = **0**, because Kipanga ends at the same point where he started.

**Making Sense of the Answer:** *Kipanga ran a long distance, but his final position did not change. Distance counts the whole journey, while displacement depends only on the start and end points.*

**Think Like a Physicist:** *Whenever an object returns to its starting point, its displacement is zero, even though the distance travelled is not zero.*

Having given the worked examples their full say, we can now welcome the next subtopic and see what fresh ideas it brings along.

## **SPEED AND VELOCITY**

**Speed** tells *how fast* an object moves. It is the rate of covering distance, so it is a scalar quantity and it is always positive or zero.

**Velocity** tells *how fast and in which direction* an object moves. It is the rate of change of displacement, so it is a vector quantity. Velocity can be positive, negative, or zero depending on the chosen direction.

Two cars may have the same **speed** but different **velocities** if they move in opposite directions. This is why speed is just a number, but velocity is a complete description of motion as it tells the *magnitude* and the *direction*

In Physics, direction is never a decoration. It can change the final answer, especially in problems involving **vectors**, **relative motion**, and **acceleration**.

Before the ideas drift away, let us anchor them using a few worked examples.

### **BINDER Example 5**

Two cars are moving along the same straight road. Car A moves at **20m/s north**, while Car B moves at **20m/s south**. Compare the **speeds** and **velocities** of the two cars.

#### **Solution**

- The **speeds** of both cars are the **same** because speed depends only on how fast they move:

$$\text{Speed} = 20\text{m/s}$$

- The **velocities** are **different** because velocity includes both magnitude and direction:

✓ Car A: **20m/s north**

✓ Car B: **20m/s south**

**Making Sense of the Answer:** *Speed ignores direction, but velocity depends on direction, so opposite directions give different velocities even if the speed is the same.*

**Think Like a Physicist:** *If two objects move with the same speed in opposite directions, their velocities have the same magnitude but opposite signs (if one direction is chosen as positive).*

**REAL Example 6**

One rainy afternoon, **Kipanga** stands still at the school gate, watching the rain fall **straight down**. A moment later, he remembers he left his exercise books at home, so he starts running fast toward home. Suddenly, the rain begins to hit his face as if it is coming **from the front**, not from above. Explain why the rain appears to fall **slanted** when Kipanga starts running.

**Solution**

When Kipanga is standing still, the rain has only a **vertical downward velocity** due to gravity, so it appears to fall straight down.

When he starts running forward, Kipanga gains a **forward velocity**. The rain is still falling downward, but relative to Kipanga, the rain now seems to have a **horizontal component** opposite to his motion. Combining the rain's downward motion and Kipanga's forward motion makes the rain appear to move **diagonally**, so it feels like it is coming from the front and hitting his face.

**Making Sense of the Answer:** *The rain has not changed its motion, but Kipanga's motion changes how he observes it; running forward makes the rain seem to "chase" him from the front.*

**Think Like a Physicist:** *Whenever two motions happen at the same time (forward motion of the observer and downward motion of rain), the observed direction becomes the **resultant** of the two velocities.*

The worked examples have said their piece; now the acceleration subtopic clears its throat and steps forward in the next module.