

UNIT 2



MOTION AND SPEED.

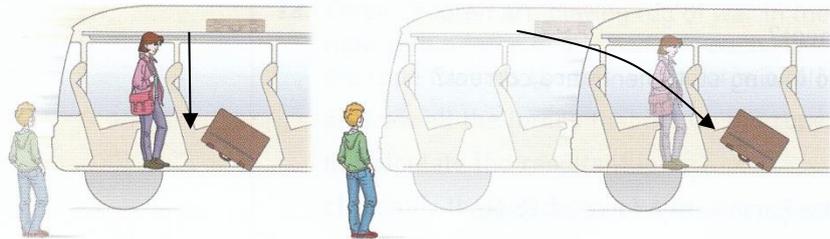


KEY CONCEPTS

- Displacement is the distance, measured in a straight line, from two positions from a moving object.
- The distance travelled is the length of a moving object's trajectory.
- Average speed is the distance travelled divided by the time taken.
- Speed is measured in m/s in the SI.
- In URM, a moving object travels identical distances in identical intervals of time.
- Acceleration is the variation of speed per unit of time. It is measured in m/s^2 .

1. WHAT IS MOTION?

Look around you and find examples of things that are moving. You can probably find countless objects in motion: the hands of the clock, the teacher while he or she is explaining the lesson, birds flying outside or cars passing by.

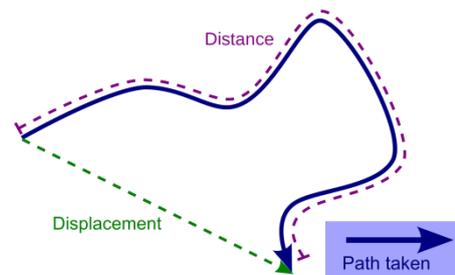


A body is **in motion** when it **changes its position** compared to a fixed point of reference that we consider at rest. A body in motion is called a **moving object**.

The **position of a body** is the place where it is with respect to a frame of reference. It is measured in terms of the distance between the moving object and the point taken as the frame of reference.

To be able to talk about the motion of an object we have to define the following terms:

- The **trajectory** is the geometric line that a moving object describes while it moves. It can be a straight line or a curve.
- Distance travelled** is the length a moving object goes along the trajectory.
- Displacement** is the distance between two different positions of a moving object, measured in a straight line.



▶▶ 2. SPEED

Speed is the quantity that tells us how quickly bodies change their position: it refers to the distance travelled in a specific time.

According to the SI of units, speed is measured in **metres/second (m/s)**, we say “metres per second”. Speed is also measured in **kilometres/hour (km/h)**, we say “kilometres per hour”.



The speedometer in a vehicle tells us exactly how fast we are travelling at any instant. Speed from a moving object in a particular moment or instant is called **instantaneous speed**.

When a car travels from one place to another it doesn't always travel at the same speed. It has no sense for us to calculate many instantaneous speeds along the journey. But we can calculate the car's average speed for the whole journey. **Average speed** is the quotient between distance travelled and time taken to do it:

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

$$v = \frac{s}{t}$$

$$\text{average speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

$$v_{av} = \frac{s}{t}$$

▶▶ 3. UNIFORM RECTILINEAR MOTION (URM)

When a body has **uniform** motion, it always moves at the **same speed**, we say speed is



constant. It travels the same distance in each unit of time, for example in each second. So, instantaneous speed is always the same and will coincide with average speed.

As its name indicates, uniform **rectilinear** motion, is movement in a **straight** line, that is, its trajectory is straight.

If a body moves at a **constant speed in a straight line**, we say it has **uniform rectilinear motion (URM)**.

▶▶ 4. ACCELERATION

You have probably seen in a car how the speed marked on the speedometer changes. If the accelerator pedal is pressed, it goes up, so the car accelerates. **Acceleration** is the change of speed per unit of time.

In the SI, acceleration is expressed in **m/s²**, we read it as “**metres per second squared**”.

To calculate the value of acceleration:

$$\text{acceleration} = \frac{\text{final speed} - \text{initial speed}}{\text{time}}$$

$$a = \frac{v - v_0}{t} \qquad a = \frac{v_f - v_i}{t}$$

Acceleration doesn't imply an increase of speed, an object has acceleration when it starts from its initial position with a speed and finishes at a different speed. The object may move more and more quickly or more and more slowly.



These cars have acceleration, positive or negative acceleration.

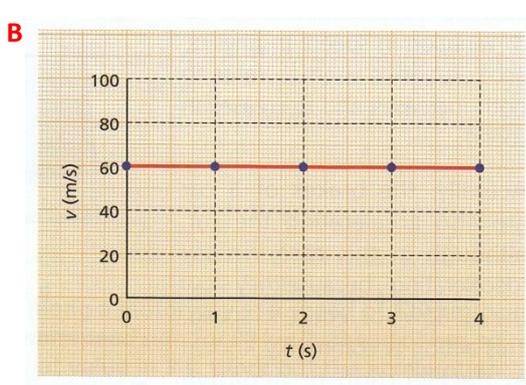
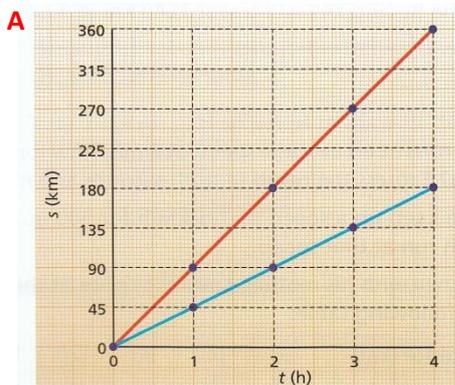
►► 5. UNIFORMLY ACCELERATED RECTILINEAR MOTION (UARM)

URM is almost an ideal motion. It is more common in our world that changes in speed could happen. When we travel by car or bus on a straight road, we accelerate to overtake other vehicles and we brake when we stop. In these situations, our instantaneous **speed isn't constant**, so we travel a **different** distance in each unit of time. This is a **variable motion**.

When a body moves in a straight line and has a constant acceleration, we say it has **uniformly accelerated rectilinear motion (UARM)**.

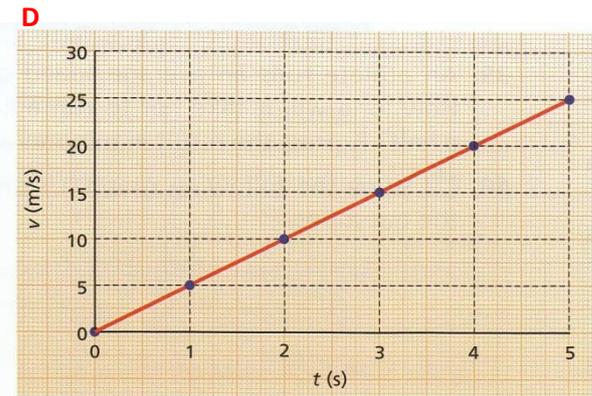
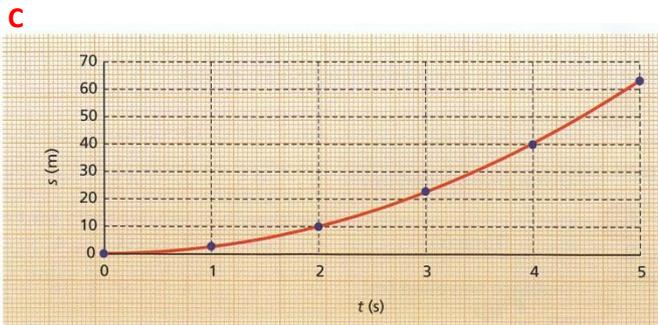
►► 6. GRAPHS TO SHOW MOTION

In order to represent motion in a graph, we have to indicate either the distance travelled by a moving object, or its speed in relation to time.



A: Distance - time (s-t) graph in a URM: distance travelled always increase the same proportion each unit of time so we can see a straight line: the greater the speed, the steeper the line.

B: Speed - time (v-t) graph in a URM: speed is always the same value, so we get a straight line parallel to the X-axis (axis for time).



C: Distance - time (s-t) graph in a UARM: in this type of graph, distance increases the more and more per unit of time because the speed increases too, so is a curved line: a parabola.

D: Speed - time (v-t) graph in a UARM: this type of graph shows how speed changes with time. The speed increases with time, so we can see a straight line: the steeper the line, the greater the acceleration.