# *KNOWLEDGE AREA*: MECHANICS
## GRADE 10 MOTION in ONE DIMENSION

# UNIT 1 ON THE MOVE
## The position of a moving object changes as time passes.

**UNIT OUTCOMES**

After working through this Unit, you should be able to

- ✓ use distance from a reference point to distinguish between moving and stationary objects
- ✓ use the equation $v = \frac{\Delta x}{\Delta t}$ to describe how fast an object changes its position
- ✓ make decisions about the units in which you express *v*, *s* and *t* when you use the above equation .

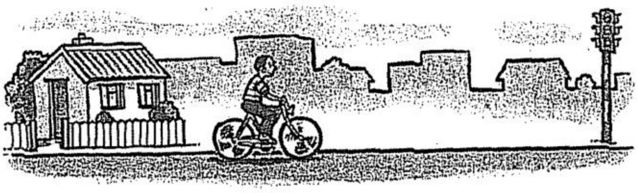
**Is it MOVING?**

We live in a world of moving objects. We see birds flying, cars stopping and starting, joggers running, seeds blowing in the wind and water flowing out of a tap. The motion of visible things such as these attracts our attention. We know that an object is moving when we see it change **position** as **time** passes. We use a **reference point** to help us decide if the object is moving. However, we are unaware of most of the moving things in our world because they are too tiny to see. For example we are surrounded by atoms and molecules in constant motion. We describe electric current as the movement of charges that are also too tiny to be seen. Evidence for the movement of these invisible things is indirect. We cannot detect changes in position of things to small for us to see!

Here we focus on the movement of everyday things around us - things big enough to be seen.

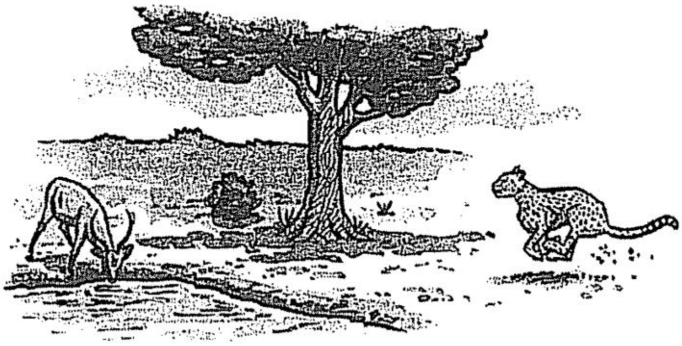
**ACTIVITY 1**

1 Imagine that you are watching the helicopter in the photograph.
   a What object in the photograph can you use as a reference point?
   b How can you tell that the helicopter is moving?



2 The picture shows a boy cycling to school.
   a What may be the boy’s position a short while later?
   b How can you tell the boy is moving?

3 A cheetah. is charging an impala drinking at a waterhole. How will the cheetah's position relative to the unsuspecting impala change with time?



4 How can you tell that the tree near the waterhole is not moving closer to the waterhole.

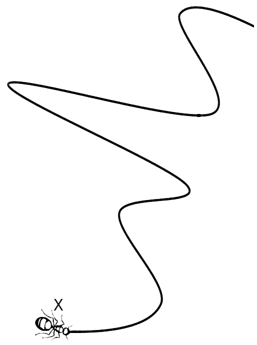
The helicopter, the schoolboy and the cheetah are **in motion**. The helicopter's **position** changes with **time**. The distance between the helicopter and the tower (a reference point) changes while you watch it. The schoolboy's **position** changes too. The **distance** between the boy and the robot (a reference point) becomes smaller and smaller as time passes. The cheetah moves closer and closer to the impala (a reference point) as **time** passes. The distance between the tree trunk and the rock in the water does not change so the tree cannot be moving. It is stationary or **at rest**.

We assume that the objects that we use as reference points are at rest although of course, they are not. Like all points on the Earth, the chosen reference points are both rotating about the Earth's axis and the Earth itself is hurtling around the Sun!

If the **distance** between an object and the reference point changes with time, the object is **in motion**.

**Distance** ($\Delta x$) is the length of the path along which something moves when it changes its position. We express distance in the same unit that we express length. This may be centimetre (cm),
millimetre (mm), metre (m) or kilometre (km). The SI unit of length and distance is the metre (m).

5 Use a piece of cotton to measure the distance the ant in Figure 5 crawls when it changes its position from P to Q.




**HOW FAST?**

We use **speed** to describe how fast something changes its position. **Speed** ( $v$ ) tells us the distance something moves in a given time interval. The equation for this is .
In everyday life we express speed in kilometre per (or in) 1 hour - km/h. We can use a car travelling at 150 km/h to explain the meaning of this equation. If the car keeps moving at this speed for 1 hour, it will travel a distance of 150 km.

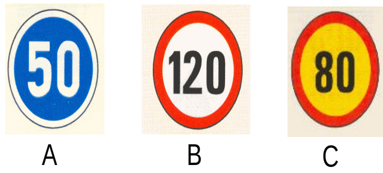
$$speed = \frac{change\ in\ position}{change\ in\ time} = \frac{distance\ moved}{time\ taken}$$

$$v = \frac{\Delta x}{\Delta t}$$

**ACTIVITY 2**

Here are three regulatory road signs in black and white.

2




1 Imagine that you see these signs in different places alongside the road.
   - a 1 What are the colours of the sign that you would expect to see near roadworks on a highway?
     - 2 What is the highest speed at which you may travel near the roadworks?
   - b What are the colours of the sign showing the minimum speed at which you may drive on a highway?
   - c Which sign shows the highest speed at which you may drive on South African roads?
   - d Use coloured pencils to draw a sign showing the speed limit in built-up areas in South Africa.

In science, we use the SI units of metre per second ( $m\cdot s^{-1}$) rather than kilometres per hour to describe speed. It is easy to change the familiar kilometres per hour into metres per second.
In 1 hour, a car travelling at 80 km per hour passed roadworks travels a distance of 80 km.
So, in (60 x 60) s - which is 1 hour, the car moves (80 x 1 000) m.
In 3 600 s the car moves 80 000 m,
So in 1 s the car moves $\frac{80\,000\,m}{3\,600\,s}$, which is 22,2 $m\cdot s^{-1}$.

2 The speedometer in a car shows that the driver is driving at 130.
   - a What are the units of this speed?
   - b Why should the driver not travel at this speed?

3 Convert the maximum speed at which you are allowed to travel on a highway in South Africa to metre per second.

4 Why do you think drivers break speed limits?

5 When you are able to drive, will you keep to the speed limits? Give reasons.

**CHOOSING SUITABLE UNITS**

Imagine that you travel at exactly 80 $km\cdot h^{-1}$ for a half hour as you pass roadworks.
In 1 hour you travel a distance of 80 km. So,
in ½ hour you travel ½ h x 80 km which is of course, 40 km. It is not necessary to use SI units to work out this distance because your travelling time is in **hours** and speed is in kilometre per **hour**.

If however, you take 25 minutes to travel (at exactly 80 km/h) past the roadworks, it is easier to express the time in **second** (the SI unit of time) than in hours. Then you must describe speed in its SI unit (metre per **second**) too.
Earlier you saw that 80 km/h is the same as 22,2 m/s. So,
in 1 s you travel 22,2 m
in 25 minutes, (25 x 60) s you travel (22,2 x 25 x 60) m = 33 300 m which you may want to express in kilometre.

**USING an EQUATION**

Earlier we use the equation $v = \frac{\Delta x}{\Delta t}$ to describe speed (*v*). When we rearrange this formula to find the distance ($\Delta x$), it becomes $\Delta x = v\Delta t$. Let's use this formula to find how far you travel at 80 $km\cdot h^{-1}$ in the vicinity of roadworks for 25 minutes. If we express 25 minutes in hours, the *h* in the numerator and the denominator cancel out, giving the distance you travel in kilometre.

$$\Delta x = v\Delta t = 80\frac{km}{h} \times 25\frac{\min}{60\min\cdot h^{-1}} = 33{,}3\ km$$

If you leave the time as 25 minutes, then you must convert the speed 80 $km\cdot h^{-1}$ into $km\cdot min^{-1}$ to work out an answer in kilometre! When you substitute quantities such as speed and time into the equation, you must remember to include not only the numbers (their magnitudes) but the units of these quantities too.

**SUMMARY TASK**

**Use ONE of the following to fill in the spaces in each statement below. position, time, speed,** $\Delta x = v\Delta t$

✓ The of a moving object changes with .

✓ describes how fast a moving object changes its position.

✓ When you use the equation to work out distance moved, the unit in which you express the time interval ($\Delta t$) must be consistent with the units of speed ($v$).