CHAPTER 02

Motion in a Straight Line

2.1 OBSERVING MOTION

People have been watching and recording things move for thousands of years. The motions of the heavens are some of the oldest recorded observations we have. Later, a need to measure the speed of advancing armies or athletes or ships required better ways of measuring distance and time. Over the centuries measurements became more accurate and now form the basis of modern physics. We can now measure distances and times to incredible accuracy.

Many types of motion are occurring around us all the time. Blood flow, moving bullets, cricket balls, athletics, cars, stars, planets, neutrinos and weaving looms are some of the areas where motion is measured. Some need to be measured carefully, others not. A car speedometer that is a few kilometres per hour over or under makes little difference but better accuracy is needed when timing a 100 metre sprint or controlling the speed of videotape through the heads of a VCR.

Sometimes the motion of objects doesn't make sense. Can you make sense of these questions?

- We live on a world that is round, yet we do not fall off. Many people used to believe the world was flat. Some still do. What evidence is there that it is round?
- Before Copernicus, most people believed that the Earth was stationary and the Sun moved around it. We now believe that the Earth is moving around the Sun but how do we know this?
- The Earth moves in a circular orbit and never slows down. Most objects in the world seem to travel in straight lines and slow down. Why is the Earth different?

The above three questions have several similarities. How many different things do they have in common?

Physics developed over the centuries as people pondered on these questions and came up with all sorts of different explanations. But people also found that knowing about the motion of everyday objects became more and more important.

It helps with your problem solving if you are familiar with some common motions and their measurements.

NEI Activity 2.1 SPEEDOMETER

Have a look at your family car's speedometer.

1. What is the maximum speed that it can record?
2. Do you know what your car's top speed is? If you don't, where would you find out? Assuming that it can't go as fast as the maximum value on the speedo, why do manufacturers use this sort in cars?
3. How many km/h are there per division?
4. The odometer (Greek *hodos* = 'a way') measures the total number of kilometres travelled by the car from when it was new. What is the maximum number of kilometres your car can travel before the odometer returns to all zeros?

Photo 2.1
A car speedometer.

5 Does your odometer measure to the nearest kilometre or tenth of a kilometre?
6 What is the maximum distance your 'trip meter' will record?
7 Some unscrupulous people illegally 'wind back' the odometer. What is the purpose of this and how do they do it?
8 Does the odometer go backwards when your car is reversed?
9 Does the speedo of your car go lower than zero when reversed?

Activity 2.2 SEWING MACHINE

Look at a sewing machine. How can you change the speed of a sewing machine motor? Is it variable? Are all electric motors controlled in the same way?

Activity 2.3 VIDEO RECORDER

If you have a VCR and can find the instruction manual, find out the tape speed on standard play. Should everyone in the class get the same result? Is the speed the same in videocameras? Are speed and image quality related?

A knowledge of physics enables us to analyse all types of motion. Without accurate measurement and control, life would be difficult indeed.

DISTANCE AND DISPLACEMENT 2.2

From the earliest times, being able to measure distances, angles and time was important in the daily lives of people. Often it was for religious reasons — worshipping sun gods; other times it was an attempt to plot the motion of the stars — a primitive astronomy. But sometimes it had a more practical purpose. Measuring distance, for instance, was important in the construction of houses, building canals and cultivating fields.

Plato told the story of how Posiedon (421 BC) inherited the island of Atlantis with its irrigated plain of 3000 by 2000 *stades* (a 'stade' is 185 metres, hence the word 'stadium'). Today, of course, we would be more likely to use metres or kilometres.

Whereas *length* is a measure of how long or wide an object is, we use the term *distance* to say how far the object has moved. A person travelling from one city to another may have moved a distance of 1200 km. In physics, we need to be able to measure not only distance but also 'displacement'.

Displacement is the change in position of an object in a given direction. You can think of it as the position measured relative to the origin. It is given the symbol '*s*'.

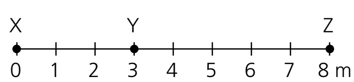

Figure 2.1

In Figure 2.1, if you started at point X and walked 8 m east to point Z and then turned around and walked 5 m west to point Y, you would have moved a distance of 13 m but would only have a displacement of 3 m east. That is, your position would only have changed by 3 m to the east. In symbols this could be written as s = 3 m E.

Displacement is called a **vector** quantity. That is, it involves both a number and a direction. Other vector quantities are velocity, acceleration and force. Quantities that do not include a direction are called **scalar** quantities. Distance, speed, mass and time are all scalar quantities. In the next chapter, vectors will be discussed in more detail.

When discussing vector quantities like displacement we use the compass points (N, E, W, S) to define directions as we did above, or alternatively, we can use a positive sign for forward motion or motion to the right and a negative sign for backward motion or motion to the left.

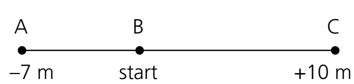

Figure 2.2

For example, in Figure 2.2 the displacement of C can be written as $s_C = +10$ m; and the displacement of A can be written as $s_A = -7$ m.

Either way, you'll need to be able to use both conventions. It's up to you and it is also up to you to define the positive and negative directions.

Representation of vector quantities

A vector quantity can be represented by a vector. A vector is an arrow. The length of the arrow represents the magnitude of the vector quantity, and the direction of the arrow shows the direction of the vector quantity. For example, the three vectors in Figure 2.3 represent cars travelling at 30 km/h east, 60 km/h west and 10 km/h north respectively.

Figure 2.3

When vectors do not lie along the compass points (N, E, S, W), angles need to be specified. Figure 2.4 shows how the direction is indicated.

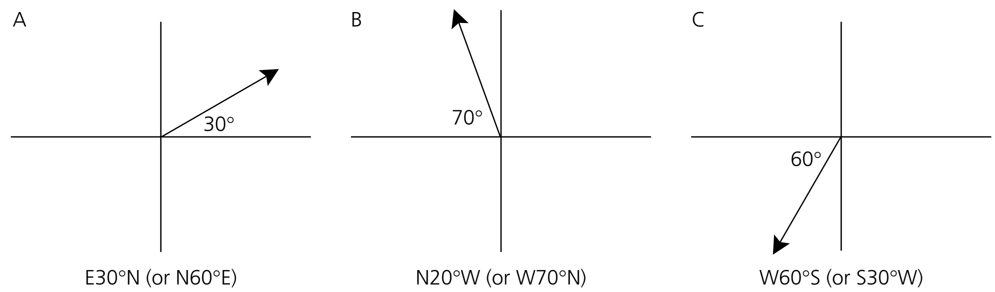

Figure 2.4

Students often find it hard to work out the directions. You can think of diagram A in Figure 2.4 as saying: going **e**ast but rotated **30°** to the **n**orth.

Example

In Figure 2.5, an orienteering competitor starts at point A and goes 2 km N, 4 km E and then 2 km S. What is the final displacement at point D?

Solution

The displacement at D is 4 km east (s_D = 4 km E).

Questions

1 In Figure 2.5:

(a) What is the displacement of the competitor at point B? (s_B = ?)

(b) What is the total distance travelled when at point D?

(c) What is the distance travelled when at point C?

(d) What is the displacement at point C? Remember to include the direction by stating the value of the angle CAD.

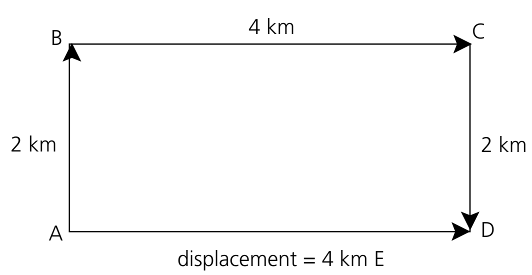

Figure 2.5
For question 1.