Chapter 1: Distance and Displacement, Speed and Velocity

Vectors

You should be familiar with the idea of a vector quantity. A vector has a size (magnitude) and also a direction.

Examples of vector quantities are:	force e.g.	15 N downwards
	velocity e.g.	8 m/s west
	displacement e.g	2 metres northwest

Scalars

Other quantities have only a size (magnitude) and the direction is unimportant. These are known as scalar quantities.

Examples of scalars are:	mass e.g.	15 kg
	speed e.g.	8m/s
	distance e.g.	2 metres

In this activity you will use the following key ideas:

Distance is the total distance travelled e.g. as measured by the milometer in a car (and is a scalar)

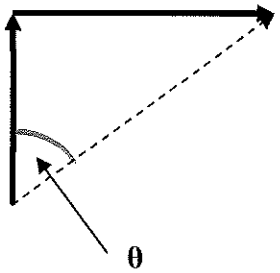
Displacement is the distance (as the crow flies) from start-point **and** direction (and is therefore a vector)
e.g. 50 m North , +10km , –50cm

Example

Look at the map of the journey below. The walker travels 3.0 km north followed by 5.0 km east.

5.0 km E

3.0 km N



The final distance travelled = 3.0 km + 5.0 km
= <u>8.0 km</u>

The final displacement can be calculated using trigonometry and pythagoras' theorem:

Bearing:
Angle **θ** can be calculated using trigonometry (SOH CAH TOA)

We know the length of the side opposite the angle (5.0 km) and the length of the side adjacent to it (3.0 km)

$\tan \theta$ = opposite / adjacent
= 5.0 / 3.0
so $\theta = \tan^{-1}(5.0 / 3.0)$
<u>θ = 59°</u>

$\text{Displacement}^2 = 3^2 + 5^2$
$\text{Displacement} = \sqrt{(3^2 + 5^2)}$
$= \sqrt{(9 + 25)}$
$= \sqrt{34}$
= **<u>5.8 km at a bearing of 59°</u>**

speed = **distance** (m) / **time** (s) (m/s)

velocity = **displacement** (m) / **time** (s) (m/s)

Velocity is the speed and direction (and is therefore a vector)
e.g. 20 m/s South, -8m/s, +15 cm/s

Example

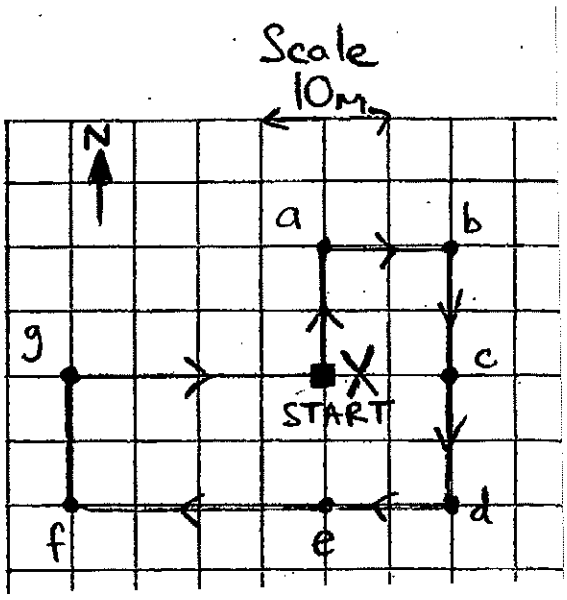
Look at the journey on the previous page. Suppose the journey took a time of 80 minutes. We can now calculate the average speed and average velocity.

Average speed = distance / time
= 8 / 80
= **0.10 km/min**

Average velocity = displacement / time
= 5.8 / 80
= **0.072 km/min**

Exercise 1

1. Look at the diagram below. It shows a journey from x, to a, b, c…and back to the start.



Calculate the displacement at the following points. You may need to use Pythagoras' theorem.

(i) a

(ii) c

(iii) e

(iv) g

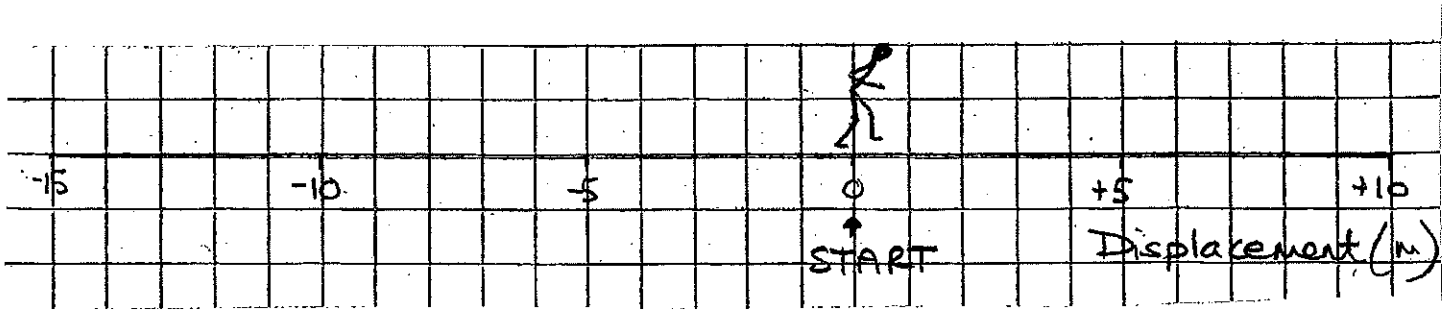
(v) x

(vi) b

(vii) d

(viii) f

2.



a) A man walks at + 2m/s (to the right) for 5 s. What will his displacement be?

b) He then walks 4m to the left. What is his new displacement?

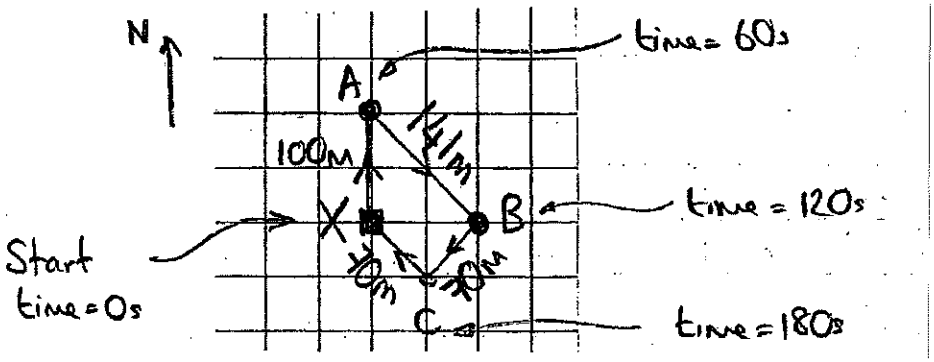
c) He now moves another 16m to the left. What is his new displacement?

d) Finally he walks back to the start. What is his displacement now?

e) How far has he walked in total? If it took him 50s, what was his average speed?

f) Average velocity = displacement / time. Calculate his average velocity for the whole journey.

3. The map below shows the location of a fox at 60 second intervals.



a) What was the fox's average speed between X and A?

b) What was the fox's average velocity between X and A?

c) What was the fox's average speed between A and B?

d) What was the fox's average velocity between A and B?

e) What was the fox's average speed between B and C?

f) What was the fox's average velocity between B and C?

g) What was the fox's average speed between X and B?

h) What was the fox's average velocity between X and B?