

Distance, Displacement, Speed and Velocity

To understand the difference between **distance** and **displacement**, or **speed** and **velocity**, you've got to know the difference between a **scalar** quantity and a **vector** quantity. Then you can race through this page.

Vectors Have Magnitude and Direction

- 1) Vector quantities have a **magnitude** (size) and a **direction**.
- 2) Lots of **physical quantities** are vector quantities:

Vector quantities: force, velocity, displacement, weight, acceleration, momentum, etc.

- 3) Some physical quantities **only** have magnitude and **no direction**. These are called **scalar quantities**:

Scalar quantities: speed, distance, mass, energy, temperature, time, etc.



Velocity is a **vector**, but **speed** is a **scalar** quantity.

Both bikes are travelling at the same **speed**, v .

They have **different velocities** because they are travelling in different **directions**.



Distance is Scalar, Displacement is a Vector

- 1) **Distance** is just **how far** an object has moved. It's a **scalar** quantity so it doesn't involve **direction**.
- 2) Displacement is a **vector** quantity. It measures the distance and direction in a **straight line** from an object's **starting point** to its **finishing point** — e.g. the plane flew 5 metres **north**. The direction could be **relative to a point**, e.g. **towards the school**, or a **bearing** (a **three-digit angle from north**, e.g. **035°**).
- 3) If you walk 5 m **north**, then 5 m **south**, your **displacement** is **0 m** but the **distance** travelled is **10 m**.

Speed and Velocity are Both How Fast You're Going

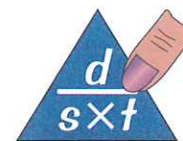
- 1) **Speed and velocity** both measure **how fast** you're going, but **speed** is a **scalar** and **velocity** is a **vector**:

Speed is just **how fast** you're going (e.g. 30 mph or 20 m/s) with no regard to the direction.

Velocity is speed in a given **direction**, e.g. 30 mph north or 20 m/s, 060°.

- 2) This means you can have objects travelling at a **constant speed** with a **changing velocity**. This happens when the object is **changing direction** whilst staying at the **same speed**.
- 3) For an object travelling at a **constant** speed, **distance**, (average) **speed** and **time** are related by the formula:

$$\text{distance travelled (m)} = (\text{average speed (m/s)} \times \text{time (s)})$$



- 4) Objects **rarely** travel at a **constant speed**. E.g. when you **walk**, **run** or travel in a **car**, your speed is **always changing**. Make sure you have an idea of the **typical speeds** for different transport methods:

1) **Walking** — **1.4 m/s** (5 km/h)

2) **Running** — **3 m/s** (11 km/h)

3) **Cycling** — **5.5 m/s** (20 km/h)

4) **Cars** in a **built-up area** — **13 m/s** (47 km/h)

5) **Cars** on a **motorway** — **31 m/s** (112 km/h)

6) **Trains** — up to **55 m/s** (200 km/h)

7) **Aeroplanes** — **250 m/s** (900 km/h)

8) **Ferries** — **15 m/s** (54 km/h)

9) **Wind speed** — **5 – 20 m/s**

10) Speed of **sound in air** — **340 m/s**

My life's feeling pretty scalar — I've no idea where I'm headed...

This all seems pretty basic, but it's vital you understand it if you want to make it through the rest of this topic.

Q1 Name two examples of: a) a scalar quantity b) a vector quantity [4 marks]

Q2 A sprinter runs 200 m in 25 s. Calculate his average speed. [2 marks]

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Warm-Up

Write each word below in the table on the right to show whether it is a scalar or vector quantity.

- acceleration time temperature
 mass weight force

Scalar	Vector

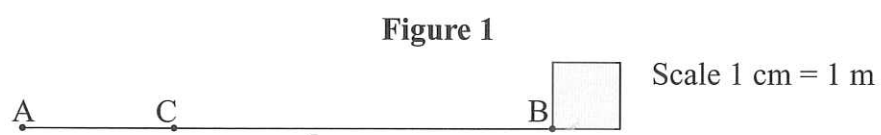
- 1 Which of the following correctly defines a vector? Grade
4-6
- A Vector quantities only have magnitude.
- B Vector quantities show direction but not magnitude.
- C Vector quantities have both magnitude and direction.
- D Vector quantities are a push or pull on an object.

[Total 1 mark]

- 2 The speed of sound varies depending upon the substance it is travelling through. State the speed of sound in air. Grade
4-6

.....
[Total 1 mark]

- 3 **Figure 1** shows the path taken by a football kicked by a child. When it is kicked at point A, the ball moves horizontally to the right until it hits a vertical wall at Point B. The ball then bounces back horizontally to the left and comes to rest at Point C. Grade
4-6



- a) Determine the distance that the ball has moved through from A to B.
- Distance = m
[1]
- b) Determine the total distance that the ball has moved through from A to C.
- Distance = m
[1]
- c) Draw a vector arrow on **Figure 1** to show the displacement of the ball.
- [1]
- d) Determine the magnitude of the displacement of the ball after it has come to rest.
- Magnitude of displacement = m
[1]

[Total 4 marks]



4 A student went for a run. She ran for exactly 22 minutes at an average speed of 4.0 m/s.

a) State the equation that links distance travelled, average speed and time.

..... [1]

b) Calculate the distance that the student ran in km. Give your answer to two significant figures.

Distance = km
[4]

[Total 5 marks]

5 A journalist is deciding whether to walk, cycle or take a bus to get to work. There are two routes he could take. The shorter route is along a 3.5 km path that only pedestrians and cyclists are allowed to use. The bus takes a longer route along a road.



a) Estimate how long it would take the journalist to walk the pedestrian route.

Time taken = s
[4]

b) Estimate how much time would be saved if the journalist were to cycle this route instead.

Time saved = s
[4]

c) Travelling to work by bus takes 15 minutes.
The total distance covered during this time is 7.2 km.
Calculate the average speed of the bus in m/s.

Speed = m/s
[3]

[Total 11 marks]





