Distance-time Graphs
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- Representing speed
- Calculating speed
- Displacement
- Summary activities
Measuring distance and time

The distance an object has travelled can be measured in lots of different ways.

Simple instruments like rulers and tape measures are useful over short distances. More sophisticated techniques are needed for larger or more accurate measurements.
Measuring time

Time is usually measured using some form of clock.

For example, a stopwatch is used to measure how fast someone runs 100 m. This can be automated by a computer to improve accuracy.

The distance an object has travelled over time can be graphed to create a distance-time graph.

Distance-time graphs can help us visualize the motion of the object.
Measuring accurately

Distance
Cars can keep track of distance by measuring the number of rotations a wheel has made and multiplying this by the wheel’s circumference. **GPS satellites** can also be used to measure large distances.

Time
Time can be measured accurately using **light gates**. They contain a light source and a sensor. When an object passes through the light gate, the sensor cannot detect light from the source, so the **time taken** for the object to pass through the light gate can be measured.
Representing speed
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Calculating speed from the gradient

The slope of a graph is called the gradient.

The gradient of the line in a distance–time graph equals the speed.

It is difficult to calculate the gradient of ‘realistic’ graphs because the line is curved.

Simple graphs use straight lines only, making it easy to calculate the gradient.
Calculating speed from graphs

What is the speed shown in these distance–time graphs?

Graph 1.4

- 1 m/s
- 8 m/s
- 2 m/s
- 10 m/s
What’s the speed?

What is the speed of the object between points B and C?

- the object has moved 60 m (70 – 10)
- it took 3 s to move this distance (6 – 3)
- speed = distance/time
  = 60/3
  = 20 m/s

If you calculate the object’s speed between points A and D, will the answer be the same?
Average speed vs. instantaneous speed

Objects often travel at **non-uniform** velocity: for example, the speed of a race car around a track will vary. The speed at a given point is called the **instantaneous speed**.

Average speed for one lap will be different to the instantaneous speeds recorded at different points around the circuit.

**Instantaneous speed** is the gradient of a distance–time graph at one point.  

**Average speed** is total distance divided by total time.
The instantaneous speed of an object can be calculated from its distance-time graph.

The steepness of the graph tells us how much distance is covered in a small amount of time. This is the speed of the object.

The steepness of the graph is technically called the gradient. We can calculate this value at any point to find the object’s speed.
Calculating gradients

To find the **gradient** of a distance-time graph, first pick the point you are interested in.

Draw a line **tangent** to this point. The tangent should touch the graph at this point only. This line represents the steepness, or the gradient, at that point.

By then drawing a triangle with this line, the calculation is very similar to calculating average speed.
Gradient of a distance-time graph

Speed is always calculated by dividing the distance travelled by the time taken. By dividing the change in distance by the change in time at a particular point, the instantaneous speed is given.

We can find the change in distance and time by subtracting the values on the triangle.

\[
\text{speed} = \text{gradient} = \frac{d_2 - d_1}{t_2 - t_1}
\]
How do speed cameras work?

There are several types of speed camera. They use different methods to calculate the instantaneous speed of a vehicle.

**Gatso speed cameras** use radar to detect the speed of a vehicle, then take two photos (half a second apart) to provide visual evidence. Lines marked on the road indicate how far the vehicle has travelled in that time.

**Truvelo speed cameras** are activated by pressure detector cables in the road. The cables are 10 cm apart and a computer calculates how long it takes the vehicle to pass from one to another, and therefore the speed of the vehicle.
Speeding and speed cameras
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**Displacement** is the net distance from the starting point. It is not the same as the distance an object has travelled.

For example, Jody roller skates 2.1km to her friend Selma’s house. Her displacement however, is only 1.1km north east. This is the ‘straight line’ distance she is from her starting point.

Like velocity, displacement measurements must include an indication of direction.
Displacement–time graphs

A displacement-time graph shows how the ‘straight line’ distance from an object’s starting point varies with time.

Mark runs a distance of 10 km at a constant speed. His route is shown below.

Since Mark’s speed was constant, a distance-time graph of his journey is a straight line.
A displacement-time graph shows how the ‘straight line’ distance from an object’s starting point varies with time.

Mark runs a distance of 10km at a constant speed. His route is shown below.

As Mark runs from point A to point B, his displacement from his starting point increases.
A displacement-time graph shows how the ‘straight line’ distance from an object’s starting point varies with time.

Mark runs a distance of 10 km at a constant speed. His route is shown below.

As Mark runs from point B to point C, the ‘straight line’ distance from him to the starting point does not change. His displacement stays the same.
Displacement–time graphs

A displacement-time graph shows how the ‘straight line’ distance from an object’s starting point varies with time.

Mark runs a distance of 10 km at a constant speed. His route is shown below.

As Mark runs from point C back to point A, he runs towards his starting point. His displacement from his starting point decreases.
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DIY distance–time graph