Chapter 9: Motion

Knowledge organiser

Speed

L distance travelled (m) = speed (m/s) × time (s)

$$s = v \times t$$

The symbol for distance is s, and the symbol for speed is v.

In reality, objects rarely move at a constant speed. So it can be useful to calculate average speed:

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

Some typical average speeds are:

- walking ≈ 1.5 m/s
- running ≈ 3 m/s
- cycling ≈ 6 m/s

The speed of sound and the speed of the wind also change depending on the conditions. A typical value for the speed of sound is 300 m/s

Velocity

The **velocity** of an object is its speed in a given direction.

Velocity is a vector quantity because it has a magnitude and direction.

An object's velocity changes if its direction changes, even if its speed is constant.

An object moving in a circle can have a constant speed but its velocity is always changing because its direction is always changing.

Acceleration

Acceleration is the change in velocity of an object per second. It is a vector quantity.

The unit of acceleration is metres per second squared, m/s^2.

An object is accelerating if its speed or its direction (or both) are changing. A negative acceleration means an object is slowing down, and is called **deceleration**.

Acceleration can be calculated using:

L $$\text{acceleration (m/s}^2\text{)} = \frac{\text{change in velocity (m/s)}}{\text{time taken (s)}}$$

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

Uniform acceleration is when the acceleration of an object is constant.

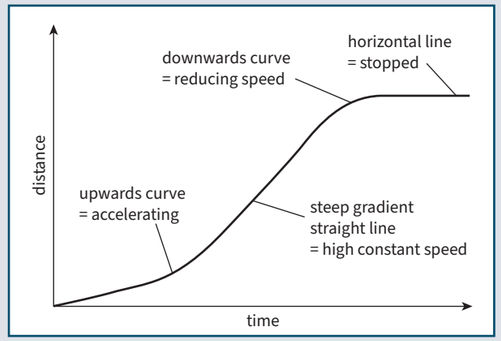
The following equation applies to objects with uniform acceleration:

$$(\text{final velocity})^2 - (\text{initial velocity})^2 = 2 \times \text{acceleration} \times \text{distance}$$

$$v^2 - u^2 = 2as$$

Distance–time graphs

A distance–time graph shows how the distance travelled by an object travelling in a straight line changes with time.

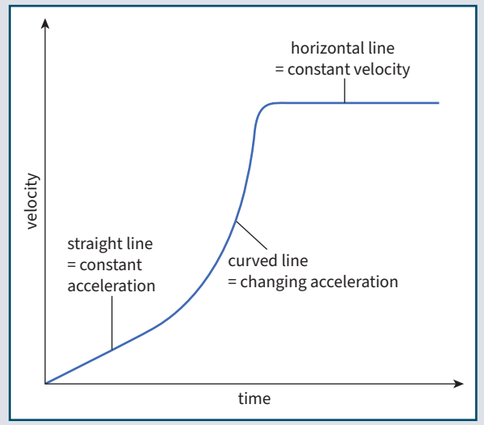


The gradient of the line in a distance–time graph is equal to the object's speed.

If the object is accelerating, the speed at any time can be found by calculating the gradient of a tangent to the curved line at that time.

Velocity–time graphs

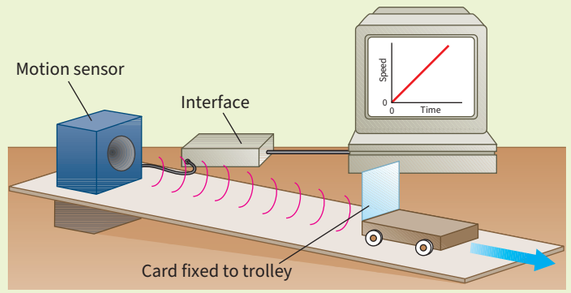
A velocity–time graph shows how the velocity of an object changes with time.



The gradient of the line in a velocity–time graph is equal to the object's acceleration.

Investigating acceleration

Motion sensors which are attached to a computer can be used to record how the velocity of an object changes.

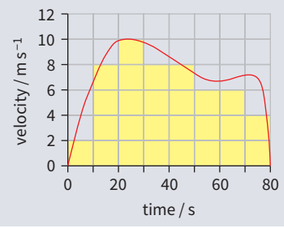


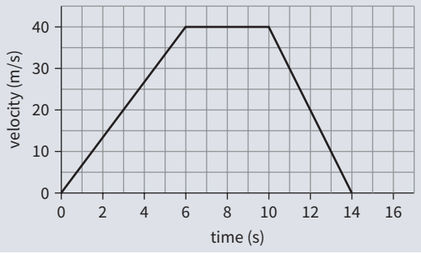
As the trolley accelerates down the runway, the velocity increases with time. Therefore, the line on the graph will go up and remain straight to suggest that the acceleration of the trolley is constant.

Alternatively, making the runway steeper will mean the trolley accelerates faster, and the line on the graph will be steeper.

Displacement (HT only)

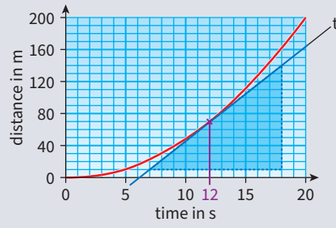
The displacement of an object, or the distanced travelled by an object, can be calculated from the area under a velocity-time graph. This can be done by measuring or counting squares.

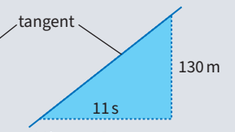




Finding the gradient of a tangent (HT only)

A **tangent** is a straight line which touches the curve at a point and is drawn in the direction of the slope at that point.





at time = 12 s,

gradient of triangle = $\frac{\text{height}}{\text{base}}$

speed = gradient of triangle = $\frac{130\text{ m}}{11\text{ s}} = 11.8\text{ m/s}$

The speed at 12 seconds is 118 m/s

Key terms

Make sure you can write a definition for these key terms.

acceleration *deceleration* *displacement* *gradient* *speed* *tangent* *uniform acceleration* *velocity*

Chapter 9: Motion

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	P9 questions	Answers
1	How do you find the speed from a distance-time graph if the object is accelerating?	Draw a tangent to the curve and find the gradient.
2	What is the difference between speed and velocity?	speed is a scalar quantity and only has a magnitude (size), velocity is a vector quantity and has both magnitude and direction
3	What factors can affect the speed at which someone walks, runs, or cycles?	age, fitness, terrain, and distance travelled
4	What are typical speeds for a person walking, running, and cycling?	1.5 m/s, 3.0 m/s, and 6.0 m/s respectively
5	What are typical speeds of a car and a train?	13–30 m/s and 50 m/s respectively
6	What is a typical speed for sound travelling in air?	330 m/s
7	What is acceleration?	change in velocity of an object per second
8	What is the unit of acceleration?	m/s^2
9	How can an object be accelerating even if it is travelling at a steady speed?	if it is changing direction
10	What is happening to an object if it has a negative acceleration?	it is slowing down
11	What information does the gradient of the line in a distance–time graph provide?	speed
12	What information does the gradient of the line in a velocity–time graph provide?	acceleration
13	How can the distance travelled by an object be found from its velocity–time graph?	calculate the area under the graph

Put paper here