Velocity-Time GRAPHS

N5 Physics
Describing graphs

Graph showing speed over time.
The motion of any object can be represented by a line drawn on a speed-time or velocity-time graph. This gives a visual indication of how objects are moving.

<table>
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<th>Speeding up</th>
<th>constant velocity</th>
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<tr>
<td>Increasing velocity</td>
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<td>Negative constant acceleration, constant deceleration</td>
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<tr>
<td>Constant Acceleration</td>
<td>Steady speed/velocity / Zero acceleration</td>
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![Speed vs Time](image1)

![Constant Velocity vs Time](image2)

![Deceleration vs Time](image3)
Describe the motion represented by the line on each speed-time graph:

0 - 8 seconds: ___________ _____ from ____ metres per second to ____ metres per second. (Constant/uniform ______________ ).

8 - 11 seconds: ___________ __________ of ____ metres per second.

11 - 18 seconds: ___________ _______ from ____ metres per second to ____ metres per second. (Constant/uniform ______________ ).
0 - 10 seconds: _________ _____ from ____ metres per second to ____ metres per second. (Constant/uniform _______________).

10 - 14 seconds: __________ _________ of ____ metres per second.

14 - 20 seconds: __________ _________ from ____ metres per second to ____ metres per second. (Constant/uniform _______________).
0 - 5 seconds: ___________ ___ from ___ metres per second to ___ metres per second. (Constant/uniform _______________).

5 - 12 seconds: ___________ __________ of ___ metres per second.

12 - 17 seconds: ___________ ___ from ___ metres per second to ___ metres per second. (Constant/uniform _______________).
0 - 5 seconds: Speeding up from rest (0 metres per second) to 10 metres per second. (Constant/uniform acceleration).

5 - 15 seconds: Steady speed of 10 metres per second.

15 - 20 seconds: Slowing down from 10 metres per second to rest (0 metres per second). (Constant/uniform deceleration).
With uniform/constant acceleration, a motorcycle takes 8 seconds to speed up from rest to 20 metres per second. The motorcycle continues to travel at this steady speed for 4 seconds. It then increases its speed to 45 metres per second (constant/uniform acceleration) in 7 seconds.
Maximum velocity 9 ms$^{-1}$, total time 18 s
A cyclist travels at a steady velocity of 9 ms$^{-1}$ for 6 s, before slowing down (negative constant acceleration) to a velocity of 2 ms$^{-1}$ in 7 s. She then travels at this constant velocity for a further 5 s.
Draw a velocity time graph for the following motion.

A car brakes at traffic lights, its velocity changes from 9 m/s to rest in 6s. It remains at rest for 14s. It then accelerates to 12 m/s in 8s.
Maximum speed = 90 metres per second. Total time = 20 seconds.

A racing car travels at a steady speed of 10 metres per second for 2 seconds before accelerating constantly/uniformly for 12 seconds to a speed of 90 metres per second. The car then immediately decelerates constantly/uniformly for 6 seconds to a speed of 70 metres per second.
Velocity-time graph challenge

1. Draw a set of axes for a velocity-time graph in your jotter.

2. In your neighbour’s jotter, neatly and using a ruler, draw in a simple journey involving at least two changes in acceleration.

3. In your own jotter write a short story which could be described by the graph your neighbour drew in your jotter.

4. LATER WE WILL calculate the accelerations and the total distance travelled on the journey, so leave space.
Now you try drawing a graph

0 - 8 seconds: ______________ from ___ metres per second to ___ metres per second. (Constant/uniform ________________).

8 - 11 seconds: ___________ __________ of ___ metres per second.

11 - 18 seconds: ___________ __________ from ___ metres per second to ___ metres per second. (Constant/uniform _______________ ).
Finding the acceleration from velocity-time graphs
The gradient of a velocity-time graph (steepness) tells us the acceleration of the object. The steeper the graph (bigger the gradient) the greater the acceleration.
Finding the gradient of a velocity-time graph

\[ \text{Gradient} = \frac{\text{rise}}{\text{run}} \]

Or

\[ m = \frac{\text{vertical}}{\text{horizontal}} \]

\[ m = \frac{y_2 - y_1}{X_2 - X_1} \]

In our case that is

vertical = (v-u)
Horizontal = t

Gradient = \( \frac{v-u}{t} \)

Gradient = acceleration
Drawing velocity-time Graphs

Draw a velocity-time graph for the following journey

- A train leaves the station and takes 30s to accelerate to 15m/s.
- It remains at this speed for a further 15 seconds.
- As it approaches the next station it slows to 5m/s. It takes 20 seconds to decelerate to this speed.
- As it finally pulls into the next station it slows to a stop in 15 seconds.
What It Should Look Like

Let’s find out the accelerations
What It Should Look Like
Describe the motion represented by the line on each speed-time graph:

0 - 10 seconds: ___________ _____ from ____ metres per second to ____ metres per second. (Constant/uniform ________________ ).

10 - 15 seconds: ___________ __________ of ____ metres per second.

15 - 20 seconds: ___________ __________ from ____ metres per second to ____ metres per second. (Constant/uniform ________________ ).
Finding the Acceleration from velocity-time graph:

Gradient = rise/run
\[a = \frac{v-u}{t}\]
\[a = \frac{10-0}{10}\]
\[a = 1 \text{ m/s}^2\]
Problems

2. Calculate (a) the acceleration over OA, AB and BC

5m/s², 0, 3.75m/s², 127.5m
Finding the distance and displacement from velocity-time graphs
Distance and Displacement from a graph

The AREA under a speed-time graph tells us HOW FAR we have travelled (DISTANCE).

The area under a velocity-time graph tells us the DISPLACEMENT of the object.
Copy out the shapes and find the area of each shape. Include your working.
Finding the area of different shapes

Q. How would you find the area of a square or a rectangle?

A. You would multiply the base by the height to find the area.
   \[ \text{Area} = b \times h \]

Q. How would you find the area of a triangle?

The triangle is half of a rectangle with the same base and height. The triangle therefore has half the area of the rectangle.

A. The area of the triangle is
   \[ \frac{1}{2} \text{ base} \times \text{height}. \]
   \[ \text{Area} = \frac{1}{2} \times b \times h \]
Q. How could you find the area of this shape (called a trapezium)?

You could divide it up into triangles and rectangles, and then find the area of each part.

A. 
Area 1 = \( \frac{1}{2} \times b \times h_1 \)
Area 2 = \( b \times h_2 \)
The AREA under a speed time graph tells us HOW FAR we have travelled (DISTANCE)

\[ v = \frac{d}{t} \]

\[ d = v \times t \]
My object is travelling very fast. It is travelling at constant speed, its instantaneous speed is constant. It’s acceleration is zero. To find the distance travelled, \( d \), we’d use the formula:

\[
v = \frac{d}{t}
\]

\[
d = v \times t
\]

\( d = 100 \times 300 = 30000 \text{m} \)
Find the average speed for this journey.

\[-v = \frac{u + v}{2}\]
\[-v = \frac{0 + 10}{2} = 5 \text{ m/s}\]

The area of the triangle is exactly the same as the area of the rectangle with a speed exactly half way between the two values, \(u\) & \(v\).

\[d = \bar{v} \times t\]
\[d = 5 \times 30 = 150 \text{ m}\]
This yellow area is the same as the pink area.

\[ d = \text{area under a speed time graph} \]

\[ d = \frac{1}{2} bh \]

\[ d = \frac{1}{2} \times 30 \times 10 \]

\[ d = 150m \]

the area of the pink shape is the same as the area of the yellow triangle. Both give you the distance travelled.
Speed/ velocity - Time Graphs

Speed time graphs, when drawn accurately can be used to find the total distance travelled during a journey. No matter what the shape of the graph....

Total distance covered = Area under a speed time graph

Often, to find the area, the graph will need to be split into standard geometrical shapes like triangles and rectangles

Make a sketch of this graph and divide it up into appropriate shapes
How far did it go? Distance!

![Graph showing speed over time with labeled sections A, B, C, D, E.](image-url)
How far did it go?

Displacement = area under v-t graph

= Triangle A + Rectangle B + Triangle C + Rectangle D + Triangle E

= \(\frac{1}{2} \times 30 \times 15\) + \(15 \times 15\) + \(\frac{1}{2} \times 10 \times 20\) + \(20 \times 5\) + \(\frac{1}{2} \times 15 \times 5\)

= 225 + 225 + 100 + 100 + 37.5

= \(687.5\) m
Problem

2. Calculate the total distance traveled in the 12 s

127.5 m
1. Calculate the average velocity over OA AB and BC
Velocity time graphs; Summary

- The gradient of a velocity time graph gives the acceleration of an object.
- The area under a velocity time graph gives the total distance travelled.
- Increasing or decreasing gradient gives the rate at which the acceleration is increasing or decreasing.
- Zero gradient means the object is travelling at...
Distance-Time
GRAPHS
Distance-time graphs

1) Diagonal line =

2) Horizontal line =

3) Steeper diagonal line =

4) Diagonal line downwards =

Distance (metres)

Time/s
Distance time graphs; Summary

- The gradient of a distance time graph gives the velocity
- *increasing* gradient means object is *accelerating*
- *decreasing* gradient means object is *decelerating*
- *zero* gradient means object is *stationary*
Problems

1. Describe the motion of the vehicle during the 12s journey
2. Calculate the average speed over OA, AB and BC
Sima and Julie wait at the bus stop.

Sima waits for her friend Julie to get ready.

Sima walks ½ mile to her friend’s house.

Sima and Julie are on the bus going to school.

Sima and Julie walk slowly to the bus stop.