

Key concept (age 14-16)

PFM4.3: Velocity-time graphs

Progression toolkit: Velocity-time graphs

Learning focus	A velocity-time graph of an object moving in one dimension can be read to find the object's velocity at any moment of time. The gradient of the graph at a given time gives the object's acceleration; and the area under the graph between any two times gives the change in the object's displacement, or the distance it has travelled.				
As students' conceptual understanding progresses they can:	<div> <div>CONCEPTUAL PROGRESSION</div> <div></div> </div>				
	Read values of speed or velocity off a speed-time or velocity-time graph, and interpret the meaning of a negative velocity. P	Describe the motion of an object from a velocity-time graph, and identify the velocity-time graph from a description of motion.	Identify the velocity-time graph corresponding to a given displacement-time graph, and vice versa.	Calculate, and explain how to work out, the acceleration of an object from the gradient of a velocity-time graph.	Calculate, and explain how to work out, the change in displacement of an object, or the distance it has travelled, from the area under a velocity-time graph.
Diagnostic questions	Reading the graph	Telling the story	From displacement to velocity	Speeding up	Are we there yet?
		Choosing the graph	From velocity to displacement		
Response activities	Drawing graphs	Drawing the story	Translating motion graphs	Using the gradient	Calculating displacement
		Shaping the graph			

Key:

P Prior understanding from earlier stages of learning

B Bridge to later stages of learning

Translating motion graphs	Using the gradient	Calculating displacement
<p>BEST STUDENT WORKSHEET</p> <p>Translating motion graphs (1)</p> <p>Some students have had a go at drawing a velocity-time graph. They want to show the same movement as this displacement-time graph.</p> <p>These are the graphs they draw:</p> <p>The students are discussing the graphs they have drawn.</p> <p>Mustafa: It has the same shape as the d-t graph because it shows the same motion.</p> <p>Lydia: At first velocity is positive and in the middle velocity is zero, so the first bit, movement is faster, because the time on the d-t graph is longer.</p> <p>Simon: I agree with Lydia mostly, but in the last part, movement is in the opposite direction so velocity is negative.</p> <p>Ryan: At first the velocity is positive and in the last part, the object is moving faster, so it must speed up in the middle.</p> <p>To answer:</p> <ol style="list-style-type: none"> Which of student has drawn the correct graph? What would you say to help the students who are wrong? What advice would you give to make the correct graph even better? <p><small>Developed by the University of York Science Education Group, the Salters' Institute and the Institute of Physics. This document has been peer-reviewed. Download the original from www.BestEvidenceScienceTeaching.org. It is licensed under the Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>	<p>BEST STUDENT WORKSHEET</p> <p>Using the gradient</p> <p>Acceleration is calculated as the change in velocity divided by the time taken for the change.</p> <p>acceleration = $\frac{\text{change in velocity}}{\text{time taken}}$</p> <p>Change in velocity, Δv, in metres/second (m/s) Time taken, Δt, in seconds (s) Acceleration, a, in metres per second squared (m/s²)</p> <p>From a graph: Two values of velocity need to be used to find the change in velocity. Two corresponding values of time are needed to work out time taken.</p> <p>Example: The velocity-time graph shows a steady acceleration. Use the graph to work out that acceleration.</p> <p>Model answer:</p> <p>Read off pairs of values from the graph At 10 minutes, $v = 0 \text{ m/s}$ At 15 minutes, $v = 30 \text{ m/s}$ Work out the 'change' and Δv in m/s $\Delta v = 30 \text{ m/s} - 0 \text{ m/s} = 30 \text{ m/s}$ Using $a = \frac{\Delta v}{\Delta t}$ Substitute values $a = \frac{30 \text{ m/s}}{120 \text{ s}}$ $a = 0.25 \text{ m/s}^2$ Acceleration = 0.25 m/s^2</p> <p><small>Developed by the University of York Science Education Group, the Salters' Institute and the Institute of Physics. This document has been peer-reviewed. Download the original from www.BestEvidenceScienceTeaching.org. It is licensed under the Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>	<p>BEST STUDENT WORKSHEET</p> <p>Calculating displacement</p> <p>The change in displacement of an object between two times, is equal to the area under a velocity-time graph between those times.</p> <p>Example: The velocity-time graph shows the movement of an object. Use the graph to work out the change in displacement.</p> <p>Model answer:</p> <p>Divide the graph into regions where:</p> <p>Calculate area of first region Displacement = $1 \text{ m/s} \times 4 \text{ minutes}$ $= 1 \text{ m/s} \times (4 \times 60 \text{ s})$ $= 1 \text{ m/s} \times 240 \text{ s}$ $= 240 \text{ m}$</p> <p>Calculate area of second region Displacement = $3 \text{ m/s} \times 2 \text{ minutes}$ $= 3 \text{ m/s} \times (2 \times 60 \text{ s})$ $= 3 \text{ m/s} \times 120 \text{ s}$ $= 360 \text{ m}$</p> <p>Work out the total displacement Change in displacement = $240 \text{ m} + 360 \text{ m}$ Change in displacement = 720m</p> <p><small>Developed by the University of York Science Education Group, the Salters' Institute and the Institute of Physics. This document has been peer-reviewed. Download the original from www.BestEvidenceScienceTeaching.org. It is licensed under the Creative Commons Attribution-NonCommercial (CC BY-NC) license.</small></p>
Talking heads	Application and practice	Application and practice