

Physics > Big idea PFM: Forces and motion > Topic PFM4: Measuring and calculating motion

Key concept (age 14-16)

PFM4.1: Velocity

Progression toolkit: Velocity

Learning focus	Velocity and displacement are vector quantities. Velocity measures by how much displacement changes in a given time interval.				
As students' conceptual understanding progresses they can:	<div> <div>CONCEPTUAL PROGRESSION</div> </div>				
	Explain the difference between distance and displacement, and between speed and velocity. P	Calculate displacement and velocity for one-dimensional motion.	Calculate average velocity and instantaneous velocity for one-dimensional motion.	Identify the difference between speed, instantaneous velocity and average velocity for two-dimensional motion.	Calculate differences in velocity for 1-dimensional and 2-dimensional motion. B
Diagnostic questions	Going in the right direction	Displacement and velocity	Average velocity and instantaneous velocity	Spaghetti junction	The difference matters
	Setting it out	There and back again	Who's going fastest?	Round the bend	Changing velocity
Response activities	How fast are they going?	Calculating average speed and average velocity		Velocity and speed in two dimensions	Bumps and orbits

Key:

P Prior understanding from earlier stages of learning

B Bridge to later stages of learning

Going in the right direction?	Setting it out	Displacement and velocity	There and back again	Average velocity and instantaneous velocity																																																		
<p>Going in the right direction?</p> <p>This passage is about distance and displacement.</p> <p>Put a tick (✓) in the box using the best word.</p> <p>You should only use the word distance or displacement.</p> <p>Distance and displacement</p> <p>When an object moves, _____ is a measure of how far it has travelled along its path. The direction it has travelled in does not matter.</p> <p>The length of a line drawn from the starting point to the end of a journey, together with the direction from start to finish, is called the _____.</p> <p>_____ has a magnitude only. _____ has both a magnitude and a direction.</p> <p>_____ is a scalar quantity. _____ is a vector quantity.</p> <p>When I write down a _____, I always have to give both its magnitude and its direction.</p> <p>Both distance and displacement can be measured in metres.</p> <p>Downloaded by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. It is licensed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>	<p>Setting it out</p> <p>a. Which of these calculations best shows how to find the velocity of the eagle?</p> <p>Put a tick (✓) in the box next to the best answer.</p> <p>A. velocity = $\frac{0.02 \text{ m}}{0.02 \text{ s}}$</p> <p>B. velocity = $\frac{0.02 \text{ m}}{0.02 \text{ s}}$ to the north east</p> <p>C. velocity = $\frac{0.02 \text{ m}}{0.02 \text{ s}}$ to the north</p> <p>D. velocity = $\frac{0.02 \text{ m}}{0.02 \text{ s}}$ to the north west</p> <p>b. What is the best reason for your last answer?</p> <p>Put a tick (✓) in the box next to the best answer.</p> <p>A. speed and velocity both have the same units</p> <p>B. velocity and speed both have a direction</p> <p>C. speed has a direction, but velocity doesn't</p> <p>D. velocity has a direction, but speed doesn't</p> <p>Downloaded by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. It is licensed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>	<p>Displacement and velocity</p> <p>A tortoise walks north at 0.1 metres per second for 20 seconds. The tortoise then turns around and walks south at the same speed for 20 seconds.</p> <p>A steady 0.1 m/s</p> <p>For the first 20 seconds, the tortoise walks north at 0.1 metres per second.</p> <p>After the first 20 seconds of its journey, what do you think about the distance and the displacement that the tortoise has travelled?</p> <p>Put a tick (✓) in the box next to the best answer.</p> <table border="1"> <thead> <tr> <th>Statement</th> <th>I am sure this is right</th> <th>I think this is right</th> <th>I'm not sure</th> <th>This is wrong</th> </tr> </thead> <tbody> <tr> <td>a. Its distance from the start is 2 metres.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>b. Its displacement from the start is 2 metres.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>c. Its distance from the start is 3 metres north.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>d. Its displacement from the start is 2 metres north.</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>Downloaded by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. It is licensed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>	Statement	I am sure this is right	I think this is right	I'm not sure	This is wrong	a. Its distance from the start is 2 metres.					b. Its displacement from the start is 2 metres.					c. Its distance from the start is 3 metres north.					d. Its displacement from the start is 2 metres north.					<p>There and back again</p> <p>A swimmer can swim 40 m up to 30 metres per second (30 m/s). A motor boat can swim 40 m up to 30 metres per second (30 m/s).</p> <p>As the swimmer, she uses a stopwatch to time the swim.</p> <p>The stopwatch reads 4 seconds when the swimmer arrives at Y.</p> <p>The stopwatch reads 4 seconds when the swimmer arrives at Y.</p> <p>What do you think about its average velocity between X and Y?</p> <p>Put a tick (✓) in the box next to the best answer.</p> <table border="1"> <thead> <tr> <th>Statement</th> <th>I am sure this is right</th> <th>I think this is right</th> <th>I'm not sure</th> <th>This is wrong</th> </tr> </thead> <tbody> <tr> <td>a. Its average velocity is 20 m/s</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>b. Its average velocity is 25 m/s to the right</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>c. Its average velocity is 25 m/s</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>d. Its average velocity is 25 m/s to the left</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>Downloaded by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. It is licensed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>	Statement	I am sure this is right	I think this is right	I'm not sure	This is wrong	a. Its average velocity is 20 m/s					b. Its average velocity is 25 m/s to the right					c. Its average velocity is 25 m/s					d. Its average velocity is 25 m/s to the left					<p>Average velocity and instantaneous velocity</p> <p>A plane is taking off. The picture shows where it is on the runway every 5 seconds.</p> <p>1. What is the plane's average velocity during the first 10 seconds?</p> <p>Put a tick (✓) in the box next to the best answer.</p> <p>A. 5 m/s to the right</p> <p>B. 10 m/s to the right</p> <p>C. 15 m/s to the right</p> <p>D. 20 m/s to the right</p> <p>2. What is the plane's instantaneous velocity after the first 10 seconds?</p> <p>Put a tick (✓) in the box next to the best answer.</p> <p>A. 5 m/s to the right</p> <p>B. 10 m/s to the right</p> <p>C. 15 m/s to the right</p> <p>D. 20 m/s to the right</p> <p>Downloaded by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. It is licensed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>
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<p>Who's going fastest?</p> <p>Five cars move along a road.</p> <p>The picture shows how the cars have travelled at different times.</p> <p>1. Which car has the highest average velocity during the first 5 seconds?</p> <p>Put a tick (✓) in the box next to the best answer.</p> <p>A. The red car</p> <p>B. The blue car</p> <p>C. Neither - they have the same speed.</p> <p>D. You can't tell from this picture.</p> <p>2. Which car has the highest average velocity for the first half of the journey?</p> <p>Put a tick (✓) in the box next to the best answer.</p> <p>A. The red car</p> <p>B. The blue car</p> <p>C. Neither - they have the same average velocity.</p> <p>D. You can't tell from this picture.</p> <p>Downloaded by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. It is licensed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>	<p>Spaghetti junction</p> <p>Two cars are travelling on different parts of a spaghetti junction.</p> <p>The picture shows the cars at three different times.</p> <p>Both cars are moving along the road at constant 10 m/s.</p> <p>1. What do you think about the speed of the two cars?</p> <p>Put a tick (✓) in the box next to the best answer.</p> <p>A. At time 1, they both have the same speed.</p> <p>B. At time 2, they both have the same speed.</p> <p>C. At time 3, the blue car has a higher speed.</p> <p>D. At time 4, they both have the same speed.</p> <p>Downloaded by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. It is licensed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>	<p>Round the bend</p> <p>A car travels around a bend at a steady speed.</p> <p>It takes the car 5 seconds to move around the bend, from X to Z.</p> <p>1. What do you think about the speed and the velocity of the car?</p> <p>Put a tick (✓) in the box next to the best answer.</p> <p>A. Its speed is the same at X, Y and Z.</p> <p>B. Its velocity is the same at X, Y and Z.</p> <p>C. Its average speed is the same as its average velocity.</p> <p>D. Its speed is the same at X, Y and Z.</p> <p>Downloaded by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. It is licensed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>	<p>The difference matters</p> <p>Two cyclists are travelling on a road.</p> <p>1. What is the magnitude of the difference between the velocities of the two cyclists?</p> <p>Put a tick (✓) in the box next to the best answer.</p> <p>A. 5 m/s</p> <p>B. 10 m/s</p> <p>C. 15 m/s</p> <p>D. 20 m/s</p> <p>2. What is the magnitude of the difference between the velocities of the two cyclists now?</p> <p>Put a tick (✓) in the box next to the best answer.</p> <p>A. 5 m/s</p> <p>B. 10 m/s</p> <p>C. 15 m/s</p> <p>D. 20 m/s</p> <p>Downloaded by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. It is licensed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>	<p>Changing velocity</p> <p>A car travels along a road and speeds up.</p> <p>What is the change in velocity of the car?</p> <p>Put a tick (✓) in the box next to the best answer.</p> <p>A. The change in velocity is 5 m/s</p> <p>B. The change in velocity is 5 m/s east</p> <p>C. The change in velocity is 5 m/s west</p> <p>D. The change in velocity is 5 m/s</p> <p>2. A car travels along a road, turns around and drives back.</p> <p>What is the change in velocity of the car?</p> <p>Put a tick (✓) in the box next to the best answer.</p> <p>A. The change in velocity is 5 m/s</p> <p>B. The change in velocity is 5 m/s east</p> <p>C. The change in velocity is 5 m/s west</p> <p>D. The change in velocity is 5 m/s</p> <p>Downloaded by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. It is licensed under a Creative Commons Attribution-NonCommercial (CC BY-NC) license.</p>																																																		
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<p>BEST STUDENT WORKSHEET</p> <p>How fast are they going?</p> <p>The picture shows the journey of two cars. The blue car starts 10 metres ahead of the red car. Both cars start at the same time. Both cars finish at the same time.</p> <p>Some students are talking about what happens when both cars start and finish at the same time.</p> <p>Sam: The red car has the highest speed because it travels further in the same time.</p> <p>Ashraf: Both cars have the same speed at the end because they finish at the same time.</p> <p>Ewan: You can't tell which car is going fastest because they don't travel the same distance.</p> <p>Corey: The blue car has the highest speed. It is ahead of the red car all the way.</p> <p>To answer:</p> <ol style="list-style-type: none"> Why do you think is right about the speed of the cars? Explain your answer. Why do you think the other students are wrong? What would you say to them to help them to understand? <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. © University of York Science Education Group, the Salter's Institute and the Institute of Physics. (2014) (1401) (1401)</small></p>	<p>BEST STUDENT WORKSHEET</p> <p>Calculating average speed and average velocity</p> <p>Average speed and average velocity can be calculated using:</p> <div style="border: 1px solid black; padding: 5px; margin: 10px 0;"> $\text{average speed} = \frac{\text{distance travelled}}{\text{time taken}}$ $\text{average velocity} = \frac{\text{total displacement}}{\text{time taken}}$ </div> <p>Speed is a scalar quantity. It has a magnitude only. Velocity is a vector quantity. It has both a magnitude and a direction.</p> <p>To do:</p> <p>Answer the questions. Show clearly every step of your calculations.</p> <ol style="list-style-type: none"> A car travels 10 kilometres east in 10 minutes. <ol style="list-style-type: none"> Find the average speed of the car in metres per second (m/s). Find the average velocity of the car in m/s. The car then travels 4 kilometres west at the same speed (10 km in 10 minutes). <ol style="list-style-type: none"> How long does it take the car to travel 4 km? Find the average velocity of the car for the whole journey. <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. © University of York Science Education Group, the Salter's Institute and the Institute of Physics. (2014) (1401) (1401)</small></p>	<p>BEST STUDENT WORKSHEET</p> <p>Velocity and speed in two dimensions</p> <p>Velocity and speed in two dimensions</p> <ol style="list-style-type: none"> A car travels around a bend, moving from X to Z. The car travels at a constant speed of 20 m/s. <ol style="list-style-type: none"> Find the average velocity of the car as it travels from X to Z. Find the instantaneous velocity of the car at X. Find the instantaneous velocity of the car at Z. Find the instantaneous velocity of the car at Y. The magnitude of the instantaneous velocity is different from the magnitude of the average velocity as the car travels from X to Z. Explain why. At what point is the direction of the instantaneous velocity equal to the direction of the average velocity? An athlete runs around a track. She runs 400 metres in 90 seconds. <ol style="list-style-type: none"> Find her average speed. Find the magnitude of her average velocity over one full lap. State the direction of her average velocity over one full lap. <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. © University of York Science Education Group, the Salter's Institute and the Institute of Physics. (2014) (1401) (1401)</small></p>	<p>BEST STUDENT WORKSHEET</p> <p>Bumps and orbits</p> <p>1. Skateboarder</p> <p>A skateboarder is going over a bump.</p> <p>To answer:</p> <ol style="list-style-type: none"> What is the direction of the velocity of the skateboarder at X? What is the direction of the velocity of the skateboarder at Y? What is the direction of the change in the velocity of the skateboarder between X and Y? <p>2. Around the Moon</p> <p>A satellite is travelling around the Moon at constant speed.</p> <p>To answer:</p> <p>What is the direction of the change in the velocity of the satellite between A and B?</p> <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This document may have been edited. Download the original from www.BestEvidenceScienceTeaching.org. © University of York Science Education Group, the Salter's Institute and the Institute of Physics. (2014) (1401) (1401)</small></p>
Response, talking heads	Application and practice - calculations	Application and practice - calculations	Application and practice