

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

Key concept (age 14-16)

PFM4.2: Acceleration

Progression toolkit: Acceleration

Learning focus	Acceleration, like displacement and velocity, is a vector quantity. Acceleration measures by how much velocity changes in a given time interval.				
As students' conceptual understanding progresses they can:	<div> <div>CONCEPTUAL PROGRESSION</div> </div>				
	Recall that acceleration in one dimension describes the motion of an object that is speeding up or slowing down. P	Describe acceleration and differentiate between displacement, velocity and acceleration.	Calculate and describe acceleration in one dimension from the equation $a = \Delta v / \Delta t$	Recognise that in one dimension, velocity and acceleration may be in different directions.	Rearrange the equation $a = (v - u) / \Delta t$ to calculate a velocity or a time.
Diagnostic questions	Going faster Accelerating tortoise Accelerating cars	Thinking about acceleration	Down, up, down Going in the right direction	New arrangements	
Response activities	Faster, slower	To the top of the hill and down again	Calculating acceleration	Which way now?	Calculating with steady acceleration

Key:

P Prior understanding from earlier stages of learning

B Bridge to later stages of learning

Going faster	Accelerating tortoise	Accelerating cars	Thinking about acceleration	Down, up, down																																																																																																				
<p>BEST TEACHER NOTES</p> <p>Going faster?</p> <p>The picture shows two cars at three different times. The times are equally spaced. The red car starts up and overtakes the blue car.</p> <p>1. What is happening when the red car is behind the blue one?</p> <p>For each statement, tick (✓) one column to show what you think.</p> <table border="1"> <thead> <tr> <th></th> <th>Let's name this is right</th> <th>I think this is wrong</th> <th>I don't know this is wrong</th> </tr> </thead> <tbody> <tr> <td>A Both cars are accelerating.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>B Neither car is accelerating.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>C The blue car has a greater acceleration than the red car.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>D The red car has a greater acceleration than the blue car.</td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>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. 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D A measure of how quickly its velocity increases.</p> <p>For each statement, tick (✓) one column to show what you think.</p> <table border="1"> <thead> <tr> <th></th> <th>Let's name this is right</th> <th>I think this is wrong</th> <th>I don't know this is wrong</th> </tr> </thead> <tbody> <tr> <td>A Both cars are accelerating.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>B Neither car is accelerating.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>C The blue car has a greater acceleration than the red car.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>D The red car has a greater acceleration than the blue car.</td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>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. 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What can you say about the velocity of each car when they are side-by-side?</p> <p>For each statement, tick (✓) one column to show what you think.</p> <table border="1"> <thead> <tr> <th></th> <th>Let's name this is right</th> <th>I think this is wrong</th> <th>I don't know this is wrong</th> </tr> </thead> <tbody> <tr> <td>A Both cars are travelling with the same velocity.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>B The red car has a greater velocity than the blue car.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>C The blue car has a greater velocity than the red car.</td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>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. 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How does the acceleration of the red car compare to the acceleration of the blue car?</p> <p>For a tick (✓) in the box next to the best answer.</p> <p>A The acceleration of the red car is two times bigger. B The acceleration of the red car is the same size. C The acceleration of the red car is two times smaller.</p> <p>For each statement, tick (✓) one column to show what you think.</p> <table border="1"> <thead> <tr> <th></th> <th>Let's name this is right</th> <th>I think this is wrong</th> <th>I don't know this is wrong</th> </tr> </thead> <tbody> <tr> <td>A Both cars are accelerating until it hits the floor.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>B No acceleration increases at five, then stays the same.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>C No acceleration is always the same as it falls.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>D No acceleration increases as it falls.</td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>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. 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<p>BEST STUDENT WORKSHEET</p> <p>Going in the right direction</p> <p>1. Which statement best describes the acceleration of the racing car?</p> <p>A racing car travelling fast along a track.</p> <p>A The racing car is accelerating to the right. B The racing car is accelerating to the left. C The racing car is not accelerating. D The racing car might not be accelerating, or it might be accelerating to the right. E The racing car might not be accelerating, or it might be accelerating to the left or to the right.</p> <p>2. Which statement best describes the motion of the lift?</p> <p>The lift is accelerating upwards.</p> <p>A The lift is moving upwards. B The lift is moving downwards. C The lift is not moving. D The lift might not be moving, or it might be moving upwards. E The lift might not be moving, or it might be moving upwards or downwards.</p> <p>For each statement, tick (✓) one column to show what you think.</p> <table border="1"> <thead> <tr> <th></th> <th>Let's name this is right</th> <th>I think this is wrong</th> <th>I don't know this is wrong</th> </tr> </thead> <tbody> <tr> <td>A Both cars are accelerating until it hits the floor.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>B No acceleration increases at five, then stays the same.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>C No acceleration is always the same as it falls.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>D No acceleration increases as it falls.</td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>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. 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It can be calculated using the equation:</p> $a = \frac{v - u}{\Delta t}$ <p>Final velocity, v (m/s) Initial velocity, u (m/s) Time taken, Δt (s) Acceleration, a (m/s²)</p> <p>The equation can be rearranged to find a velocity or a time.</p> <p>Which two of these equations are correct?</p> <p>A $\Delta t = \frac{v - u}{a}$ B $v = \Delta t(a + u)$ C $u = v - a\Delta t$ D $v = a + \frac{u}{\Delta t}$</p> <p>For each statement, tick (✓) one column to show what you think.</p> <table border="1"> <thead> <tr> <th></th> <th>Let's name this is right</th> <th>I think this is wrong</th> <th>I don't know this is wrong</th> </tr> </thead> <tbody> <tr> <td>A Both cars are accelerating until it hits the floor.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>B No acceleration increases at five, then stays the same.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>C No acceleration is always the same as it falls.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>D No acceleration increases as it falls.</td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. 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William: The slower the trolley goes, the smaller its acceleration is.</p> <p>To answer:</p> <p>1. Who is right about the acceleration of the trolley? Explain your answer. 2. Who is wrong about the acceleration of the trolley? What would you say to help them understand?</p> <p>For each statement, tick (✓) one column to show what you think.</p> <table border="1"> <thead> <tr> <th></th> <th>Let's name this is right</th> <th>I think this is wrong</th> <th>I don't know this is wrong</th> </tr> </thead> <tbody> <tr> <td>A Both cars are accelerating until it hits the floor.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>B No acceleration increases at five, then stays the same.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>C No acceleration is always the same as it falls.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>D No acceleration increases as it falls.</td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>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. 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Rolling down the slope, the ball is _____. 5. As it moves quickly towards the bottom of the slope it is _____.</p> <p>For each statement, tick (✓) one column to show what you think.</p> <table border="1"> <thead> <tr> <th></th> <th>Let's name this is right</th> <th>I think this is wrong</th> <th>I don't know this is wrong</th> </tr> </thead> <tbody> <tr> <td>A Both cars are accelerating until it hits the floor.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>B No acceleration increases at five, then stays the same.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>C No acceleration is always the same as it falls.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>D No acceleration increases as it falls.</td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>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. 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Acceleration is measured in metres per second squared.</p> <p>Example: At the top of a slope, a roller coaster is travelling at 2 m/s. It speeds up as it moves down a straight slope. After 3 seconds, it is travelling at 37 m/s. What is the magnitude of the acceleration of the roller coaster?</p> <p>Model answer:</p> <p>Initial velocity, $u = 2$ m/s Final velocity, $v = 37$ m/s Time taken, $\Delta t = 3$ s Magnitude of acceleration, $a = ?$ m/s²</p> <p>$a = \frac{\Delta v}{\Delta t}$ $a = \frac{37 - 2}{3}$ $a = \frac{35}{3}$ Magnitude of acceleration is 11.7 m/s²</p> <p>For each statement, tick (✓) one column to show what you think.</p> <table border="1"> <thead> <tr> <th></th> <th>Let's name this is right</th> <th>I think this is wrong</th> <th>I don't know this is wrong</th> </tr> </thead> <tbody> <tr> <td>A Both cars are accelerating until it hits the floor.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>B No acceleration increases at five, then stays the same.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>C No acceleration is always the same as it falls.</td> <td></td> <td></td> <td></td> </tr> <tr> <td>D No acceleration increases as it falls.</td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. 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Which way now?

BEST STUDENT WORKSHEET

Which way now?

Acceleration is a vector. It has a size and a direction.

If velocity is increasing towards the right, acceleration is to the right.

Increasing velocity

If velocity is decreasing towards the right, acceleration is to the left. This is because the change in velocity is towards the left.

Decreasing velocity

Application and practice

Calculating with steady acceleration

BEST STUDENT WORKSHEET

Calculating with steady acceleration

Acceleration is the rate of change of velocity. It can be calculated using the equation:

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

Final velocity, v (m/s)
Initial velocity, u (m/s)
Time taken, Δt (s)
Acceleration, a (m/s²)

The equation can be rearranged to find a velocity or a time.

Finding a velocity

Example: A car is travelling at 20 m/s. It accelerates at 2 m/s² for 4 s. What is the magnitude of the final velocity of the car?

Model answer:

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

Rearrange both sides to get: $(a \times \Delta t) = \frac{v - u}{1}$

Substitute both sides: $(2 \times 4) = \frac{v - 20}{1}$

Final value: $v = (2 \times 4) + 20$

Substitute the appropriate values: $v = 8 \text{ m/s} + 20 \text{ m/s}$

Magnitude of the final velocity, $v = 28 \text{ m/s}$

Initial velocity, $u = 20 \text{ m/s}$
Acceleration, $a = 2 \text{ m/s}^2$
Time taken, $\Delta t = 4 \text{ s}$
Magnitude of the final velocity, $v = ? \text{ m/s}$

Application and practice - calculations