*Physics > Big idea PFM: Forces and motion > Topic PFM2: Moving by force*

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| **Key concept (age 11-14)** |
| **PFM2.1: Describing speed** |

**What’s the big idea?**

A big idea in physics is force, because it is the key to explaining changes in the motion or the shape of an object. The motion of an object can be explained or predicted if you know the sizes and directions of all the forces that act on it. Understanding forces helps us to predict and control the physical world around us.

**How does this key concept develop understanding of the big idea?**

This key concept helps to develop the big idea by building on existing understanding of what speed is, in order to develop clear and accurate descriptions of motion that are needed to understand motion graphs and dynamic systems.

The conceptual progression starts by checking understanding of what speed is. It then supports the development of the speed-equation in order to enable comparison of different speeds and a qualitative understanding of acceleration.

**Using the progression toolkit to support student learning**

Use diagnostic questions to identify quickly where your students are in their conceptual progression. Then decide how to best focus and sequence your teaching. Use further diagnostic questions and response activities to move student understanding forwards.

**Progression toolkit: Describing speed**

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| **Learning focus** | Speed is a measure of how fast an object travels: how far it goes in a given time | | | | |
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| **As students’ conceptual understanding progresses they can:** | **C o n c e p t u a l p r o g r e s s I o n** | | | | |
| Identify an object that has a higher speed because it travels further in a given time  **P** | Identify an object that has a higher speed than another when they travel different distances in different times | Calculate the average speed of an object using speed = distance ÷ time | Explain why the average speed may be different to the instantaneous speed of an object | Identify when speed is changing the most quickly and acceleration is biggest |
|  |  |  |  |  |  |
| **Diagnostic questions** | High speed one | High speed two | Moving things | 100m world record | Speed or acceleration? |
|  |  |  |  | Acceleration |
|  |  |  |  | Biggest acceleration |
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| **Response**  **activities** |  |  | Measuring top speed | Timing problems | Is it accelerating?  **B** |

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| Key: | | | |
| **P** | Prior understanding from earlier stages of learning | **B** | Bridge to later stages of learning |

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| **High speed one** | **High speed two** | **Moving things** | **100m world record** | **Speed or acceleration?** |
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| Two tier multiple choice | Simple multiple choice | Simple multiple choice | Focused cloze | Focused cloze |
| **Acceleration** | **Biggest acceleration** | **Measuring top speed** | **Timing problems** | **Is it accelerating?** |
|  |  |  |  |  |
| Simple multiple choice | Two tier multiple choice | Sequencing process: practical | Sequencing process: demo. |  |

**What’s the science story?**

If we want to explain why objects move as they do, we first need to be able to describe motion clearly and accurately.

One useful measure is the distance an object has travelled since a chosen starting moment.

Another is the speed of an object. The speed of an object is a measure of how far it moves in a given time interval. An object’s speed might change during a given time interval, so what we measure is really its average speed during that time interval. Average speed is defined as: distance travelled ÷ time taken.

To find the speed of an object at a particular moment in time (its instantaneous speed), we measure its average speed over a very short time interval around that moment.

**What does the research say?**

When talking about speed the language that we use is important as what is clear to us may be easily misunderstood by students. Constant speed may be seen as ‘moving all the time’ and steady speed may be taken as ‘not too fast’. Going faster is often seen as ‘catching up’ and when one object overtakes another they are often described as having the same speed at the point of overtaking (Driver et al., 1994b). Making sure that students have a clear qualitative understanding of speed is necessary before introducing quantitative approaches (Driver et al., 1994a).

In their studies students are required to use graphical and numerical representations to compare and calculate speeds, and sometimes teachers and textbooks put great attention on the mathematical procedures involved rather than first developing a clear conceptual notion of speed (Stump, 1999; Lingefjard and Farahani, 2018). Students have a strong tendency to view motion graphs as pictures and superimpose existing physical knowledge onto the shape of the graph (Clement, 1986). To get from the ideas that a graph is a picture to understanding how motion graphs depict relationships between values, students should, before tackling motion graphs, be able to explain how speed relates to distance and time and have experience of measuring speed and interpreting observations.

‘[Students] need more than a routine manipulation of numbers. They need to think of an object at a greater speed both getting to a particular point in a shorter time and going further in the same time, so as to have an understanding of the practical implications of speed as distance covered in a unit time.’ (Driver et al., 1994b)

Practical work gives students the opportunity to measure distance and time in order to calculate average speeds of moving objects and to observe their motion in detail (Kibble, 2011; Driver et al., 1994b). Introducing and rehearsing vocabulary that allows them to describe observations accurately is an essential first step towards understanding motion. Students do not usually make a clear distinction between speed and acceleration. Often students do not use the word acceleration outside of their science lessons, and instead talk about speeding up or slowing down. Acceleration may be seen as ‘going fast’ (Driver et al., 1994b).

In the progression toolkit ‘describing speed’, the concept of speed in *qualitative terms* comes first. Describing the reasons why we know some objects move at a higher speed than others leads students to a clear description of speed and the speed-equation. Practical activities that require students to measure speed are included to reinforce this understanding. Examining further examples of motion introduces students to changing speeds. Some students may be able to identify when objects are accelerating, whilst others might define acceleration in qualitative terms and through discussion develop an understanding of negative acceleration.

**Guidance notes**

The focus of this key concept is on *qualitative* descriptions of speed and acceleration. Enabling students to describe motion and changes to motion accurately in a range of situations is essential to a good understanding of dynamics.

Acceleration is explored in more detail in later key concepts in this topic.

**References**

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