Physics > Big idea PFM: Forces and motion > Topic PFM1: Forces

Key concept (age 11-14)
PFM1.1: What forces do

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.

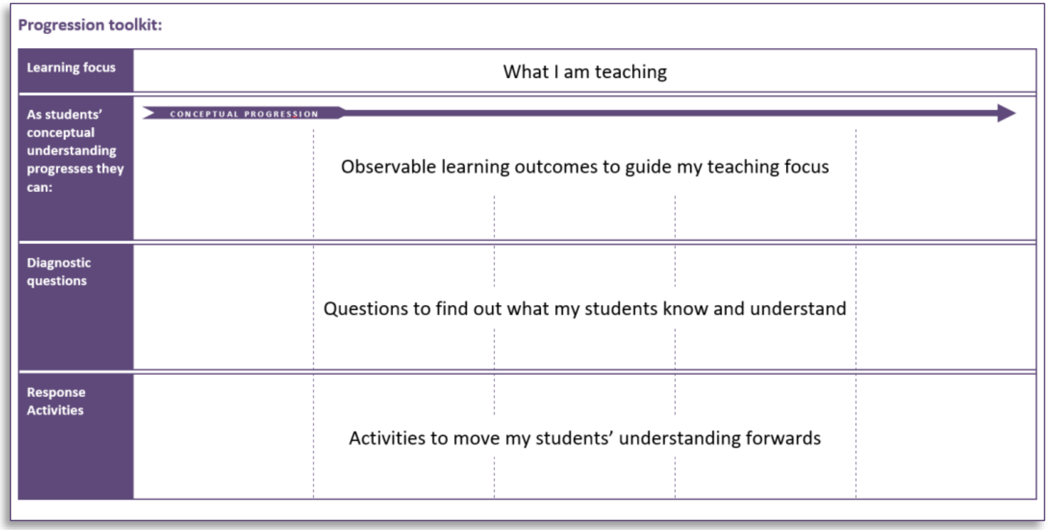
How does this key concept develop understanding of the big idea?

This key concept develops the big idea by building on existing experiences of what forces do, in order to provide the foundations for understanding how to accurately predict the effect of forces on objects, in new situations.

The conceptual progression starts by checking understanding of what makes the motion of a moving object harder to change. It then develops the concept of what a force does in order to enable understanding of what happens to the motion of an object when more than one force acts on it in a straight line.

How can you use 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: What forces do

Learning focus	A force makes things change: the speed, direction and/or shape of an object.				
As students' conceptual understanding progresses they can: (CONCEPTUAL PROGRESSION →)	Recognise that the motion of objects that are heavier and/or moving faster are harder to change. **P**	Identify situations in which a force (push or pull) is acting. **P**	Describe the changes, in a range of situations, which a force makes to the speed, direction and/or shape of an object.	Predict correctly the changes caused by forces of different sizes and direction on an object.	Explain changes caused by more than one force acting on an object at the same time. **B**
Diagnostic questions	Momentum	Is it a force?	What does this force do?	Big force, little force	An extra force
Response activities	Force or momentum?			Cycling forces	

Key:

P Prior understanding from earlier stages of learning

B Bridge to later stages of learning

What's the science story?

To start an object moving, something has to push or pull it. When this happens, we say that a force acts on the object. Similarly, to slow down or stop a moving object, or to change the direction in which an object is moving, a force has to act on it.

The motion of objects that are heavier and/or moving faster are harder to change.

A force acting on an object can also change its shape. Two forces acting on an object can hold it in a distorted shape (e.g. by stretching, compressing, or twisting).

We cannot see a force, just its effects. A change in the motion or shape of an object indicates that a force is acting on it.

What does the research say?

Gunstone and Watts (1985) clearly describe the challenges of teaching forces successfully. They note many other researchers who suggest it is more difficult to change students' beliefs in introductory mechanics than in any other area of science. It is a topic that students have very strong ideas about, often with many misunderstandings. Misunderstandings based typically on students' interpretations of their own experiences, and for this reason ones that can be very difficult to overcome.

Young students often associate the word 'force' with living things in the sense that they imagine some objects have 'power' to make things move or can actively 'try to' bring about a particular action. For example they might describe a ball that is thrown upwards as 'resisting' the force of gravity (Driver *et al*, 1994). Often forces are also linked to 'active' objects like cars which can move themselves, or make other things move.

Research shows (Gunstone and Watts, 1985, Driver *et al*, 1994) students often think that a moving object *has* force that keeps it moving, and which runs out when it comes to rest. Osborne (1985) found that as students get older they *increasingly* hold the view that a force, pushing in the direction of motion, is needed to keep an object moving. In a study of 200 students he found 46% of 13 year olds believed this, increasing to 53% of 14 year olds and 66% of 15 year olds.

In earlier teaching, students are likely to have described forces as pushes or pulls. But as Shevlin (1989) notes, students do not necessarily associate some very quick actions, such as 'kicks' or 'throws', with pushes.

In class students often learn the 'physicist's perspective' and apply it to obviously 'physics type' problems, but continue to interpret the real world in other ways. Force is a word that is used in a range of familiar contexts, but one that has a *specific* meaning in science. A student's conviction in a misunderstanding can be so strong that they make wrong observations in order to align the results with their world view. For example, when dropping two externally identical balls, they may convince themselves that they see the heavier one hit the ground first.

Understanding the forces acting on objects at rest is also challenging. Many students think of forces that push or pull, and cause changes in movement, as different to forces that hold things in place. For example in a Norwegian study (Sjoberg and Lie, 1981) half of 1000 upper secondary students did not recognise the upward force of a table acting on a book that was resting on it.

In the progression toolkit 'what forces do', the concept of momentum in *qualitative terms* comes first. Driver *et al* (1994) refer to many studies that suggest teaching momentum first allows force to be seen as the thing that causes a *change* in momentum, and prevents the label *'force'* being used by students to describe 'something inside a moving object that keeps it moving'. After thinking about what makes the motion of an object harder to change, some students may need to practise identifying forces and describing how single forces make things *change*. Other students may be able to describe the effects of forces straight away. Challenging students to predict the effect of different sized forces acting singly and then in pairs on an object should reinforce their learning and enable them to apply their thinking to unfamiliar situations.

Guidance notes

Students are likely to have persistent misunderstandings about what the scientific understanding of a force is. They may hold strong ideas about forces based on how the word is used in different contexts, and/or on the ideas they have inferred from their experiences. It is worth spending class time making sure students have a very clear understanding of what forces do. A lot of practise of using this understanding in a wide range of everyday situations helps to embed strategies necessary for dealing with more complex examples later on.

Teaching momentum (qualitatively) **before** force gives students a label for the property of an object that keeps it moving or at rest. This is quite intuitive for students who are likely to have experienced, for example, how shopping trolleys become harder to manoeuvre as they are loaded with more shopping. Force can then be introduced as the thing that **changes** movement (or shape). This approach can help students to think about force as an interaction between two objects and not an intrinsic property of one object.

The important thing at this stage is to emphasise that **'forces make things change: speed, direction and/or shape'**.

References

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