*Physics > Big idea PFM: Forces and motion > Topic PFM3: More about force*

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| **Key concept (age 11-14)** |
| **PFM3.3: Turning effects** |

**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 students’ intuitive understanding of turning effects, in order to develop a clear understanding of levers as force multipliers.

****The conceptual progression starts by checking understanding that pushing further from a pivot makes it easier to open doors or turn levers. It then supports the development of quantitative ideas about how lengths of levers and applied forces affect the size of turning effect, in order to enable understanding and application of the equation for calculating turning effects.

**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: Turning effects**

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| **Learning focus** | If a force acts on a pivoted object, the object turns about its pivot: the size of the turning effect depends on the size of the force and on its (perpendicular) distance from the pivot. | | | | |
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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** | | | | |
| Recall that a bigger applied force and/or a longer lever gives a larger turning effect.  **P** | Identify levers and their pivots, and describe what they do. | Predict the relative size of different turning effects by comparing forces applied and lengths of levers. | Predict where to place different sized weights on either side of a pivoted beam, in order to make it balance. | Calculate the size of the turning effect.  **B** |
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| **Diagnostic questions** | Open door | What’s a lever? | Wire cutters | To tip or not to tip? | See-saw calculations |
|  | Lids off |  |  |  |  |
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| **Response**  **activities** |  |  | Balance beam | | Wheelbarrow |

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

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| **Open door** | **Lids off** | **What’s a lever?** | **Wire cutters** | **To tip or not to tip?** |
|  |  |  |  |  |
| Simple multiple choice | Simple multiple choice | Simple multiple choice | Confidence grid | Two-tier multiple choice |
| **See-saw calculations** | **Balance beam** | **Wheelbarrow** |  |  |
|  |  |  |  |  |
| Linking ideas and  simple multiple choice | Predict, explain; observe, explain | Sequencing |  |  |

**What’s the science story?**

If a rigid object is pivoted at a fixed point, a force acting on it at any other point will make it rotate. The turning effect of a force is called the moment of the force. It is defined as: force x perpendicular distance from the pivot to the line of action of the force

If an object is stationary, the sum of the moments of all the forces turning it in a clockwise direction is equal to the sum of the moments of all the forces turning it in an anticlockwise direction.

**What does the research say?**

From an early age students often have an intuitive understanding of turning effects through their everyday interactions with doors, see-saws and other mechanical devices (Inhelder and Piaget, 1958; Driver et al., 1994a; Institute of Physics). In England students investigate levers as force multipliers at age 9-10 (Department for Education, 2013b); before progressing they need to be able to put into words their intuitive understanding that an effort further from a pivot leads to a bigger turning effect (Driver et al., 1994b). Driver et al. also point out that building understanding of turning effects from students’ intuition is more effective than limiting teaching to arithmetic manipulation of the formula: moment = force x perpendicular distance from the pivot.

When teaching, it may be helpful not to use the term ‘moment’ to describe turning effects because students often associate the term with ‘time’, or confuse it with ‘movement’. Using ‘turning effect’ can be less problematic (Driver et al., 1994b).

Students often find it challenging to identify less obvious forms of lever. Text books often use examples that they are not familiar with, such as handles on car-jacks or bottle openers. It is better to elicit examples familiar to the students. It can help to set them the task or identifying levers in their own home (taps, doors, tin-openers) and giving them the opportunity to describe the levers involved and explain how they work (Institute of Physics; Effrosyni, Archer and King, 2017).

This leads to the next step, which is identifying and developing an understanding of the measureable forces (effort and load), the distances from the pivot, and the relative distances moved by the load and the effort. Students need to develop understanding of how the distance from the pivot and the applied force combine to produce a turning effect. These are compensating variables because when a force is applied at a greater distance from a pivot it requires less effort for it to achieve the same turning effect as another force applied closer to the pivot (Driver et al., 1994b). It is important to make explicit that when a smaller applied force is needed because a longer lever is being used, the applied force has to be moved through a greater distance than a bigger force acting on a shorter lever. This is necessary in order to subvert the misconception that you can get ‘something for nothing’ (Institute of Physics).

Giving students first-hand experience of balancing different sized weights on a pivoted beam can help students move from a qualitative to a quantitative understanding of turning effects.

**Guidance notes**

In England students investigate levers as force multipliers in KS2 science (Department for Education, 2013b). The calculation of moments has been moved from KS3 science into KS4 and appears only in the subject content for single subject physics (Department for Education, 2013a; Department for Education, 2015a; Department for Education, 2015b).

**References**

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