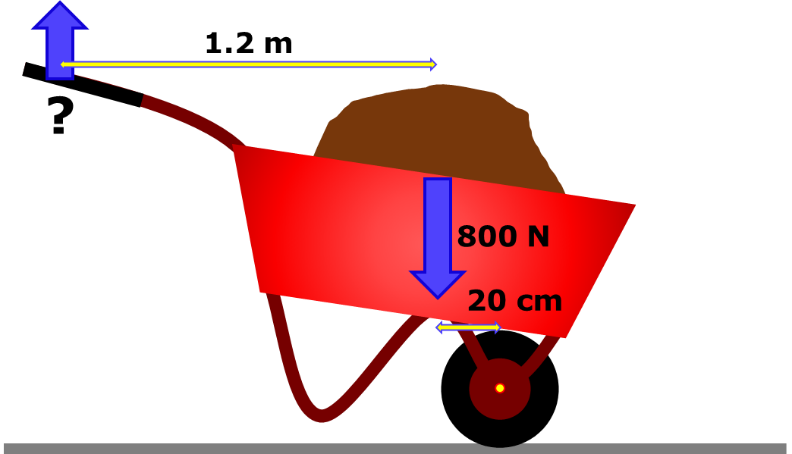
**Wheelbarrow**

A wheelbarrow makes it easier to lift a heavy pile of soil.

How can you work out what force is needed to lift 80 kg of soil?

Lifting 80 kg straight up needs a force of 800 Newton.



**To do**

Use these statements to describe **how to calculate the force needed to lift the wheelbarrow**.

Some of the statements are *not* needed.

|  |  |  |
| --- | --- | --- |
| The turning effect = length of the lever x the force to lift the wheelbarrow. |  | The force to lift the wheelbarrow = length of the lever x the weight of soil. |
|  |  |  |
| Work out the turning effect of the soil. |  | Change 20 cm into metres. |
|  |  |  |
| The force to lift the wheelbarrow = turning effect ÷ by length of the lever. |  | The turning effect needed to lift the wheelbarrow = turning effect of soil. |
|  |  |  |
| The length of the lever is 1.2 m. |  | The length of the lever is about 1.7 m. |
|  |  |  |
| Add 1.2 m to 0.2 m to find the length of the lever. |  | Multiply 0.2 m by 800 N. |
|  |  |  |
| Divide both sides by the length of the lever. |  | Multiply 20 cm by 800 N. |

Sort cards for: **Wheelbarrow**

|  |  |
| --- | --- |
| The turning effect = length of the lever x the force to lift the wheelbarrow. | The turning effect = length of the lever x the force to lift the wheelbarrow. |
| Work out the turning effect of the soil. | Change 20 cm into metres. |
| The force to lift the wheelbarrow =  turning effect ÷ by length of the lever | The turning effect needed to lift the wheelbarrow = turning effect of soil. |
| The length of the lever is 1.2 m. | The length of the lever is about 1.7 m. |
| Add 1.2 m to 0.2 m to find the length of the lever. | Multiply 0.2 m by 800 N. |
| Divide both sides by the length of the lever. | Multiply 20 cm by 800 N. |

Sort cards for: **Wheelbarrow**

|  |  |
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| The force to lift the wheelbarrow =  turning effect ÷ by length of the lever | The turning effect needed to lift the wheelbarrow = turning effect of soil. |
| The length of the lever is 1.2 m. | The length of the lever is about 1.7 m. |
| Add 1.2 m to 0.2 m to find the length of the lever. | Multiply 0.2 m by 800 N. |
| Divide both sides by the length of the lever. | Multiply 20 cm by 800 N. |

*Physics > Big idea PFM: Forces and motion > Topic PFM3: More about force > Key concept PFM3.3: Turning effects*

|  |
| --- |
| **Response activity** |
| **Wheelbarrow** |

**Overview**

|  |  |
| --- | --- |
| 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. |
| Observable learning outcome: | Calculate the size of the turning effect. |
| Activity type: | Sequencing |
| Key words: | balance, force, lever, pivot, turning effect |

This activity can help develop students’ understanding by addressing the sticking-points revealed by the following diagnostic question:

* Diagnostic question: See-saw calculations

**What does the research say?**

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., 1994).

When students are able to identify levers and describe what they do with confidence, the next step is to identify and develop 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., 1994). 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).

**Ways to use this activity**

Students should practise simple calculations to work out turning forces. Some examples may include the conversion of centimetres into metres to make units consistent; harder ones may require the distance to the pivot to be found by adding or subtracting labelled distances.

After practising calculations, students should complete the sequencing activity in pairs or small groups, and the focus should be on the discussions. The statements are also provided as cut-out cards for students to physically organise.

Listening in to the conversations of each group will often give you insights into how your students are thinking. Each member of a group should be able to explain why the statements were put in the chosen order. Once this activity has been completed it may be helpful to challenge students to independently write down their own method, or to carry out harder calculations similar to this one.

*Differentiation*

You may choose to use simplified statements for some students, or give them the starting statement to start them off. In some situations it may be more appropriate for a teaching assistant to read the statements with one or two students.

**Expected answers**

An approximate order is:

1. Work out the turning effect of the soil.
2. Change 20 cm into metres.
3. Multiply 0.2 m by 800 N.
4. The turning effect needed to lift the wheelbarrow = turning effect of the soil.
5. Add 1.2 m to 0.2 m to find the length of the lever.
6. The turning effect = length of the lever x the force to lift the wheelbarrow.
7. Divide both sides by the length of the lever.
8. The force to lift the wheelbarrow = turning effect ÷ by the length of the lever.

~~The force to lift the wheelbarrow = length of the lever x the weight of the soil.~~

~~The length of the lever is 1.2 m.~~

~~The length of the lever is about 1.7 m.~~

~~Multiply 20 cm by 800 N.~~

NB 1.7 m is the distance from the upwards force arrow to the pivot measured diagonally across the wheelbarrow, but the length of lever needed in the calculation is the *perpendicular* distance to the pivot which is 1.4 m.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Image: Peter Fairhurst (UYSEG).

**References**

Driver, R., et al. (1994). *Making Sense of Secondary Science: Support Materials for Teachers,* London: Routledge.

Institute of Physics. *Supporting Physics Teaching 11-14: Machines, Levers* [Online]. Available at: <http://supportingphysicsteaching.net/MaHome.html> [Accessed June 2019.