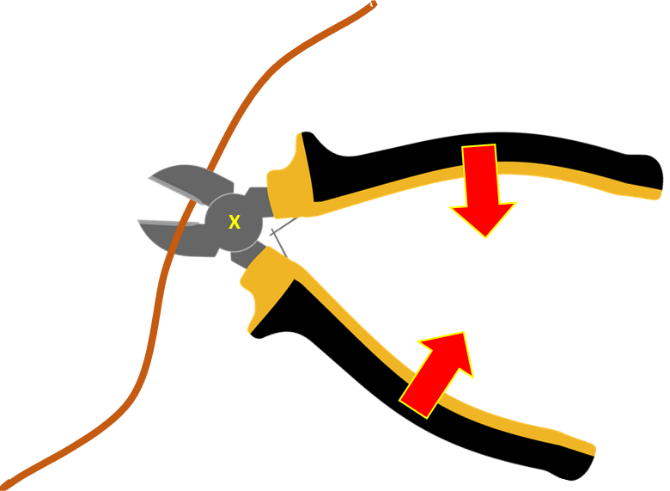
**Wire cutters**

Hannah is struggling to cut a thick wire.

She squeezes the wire cutters in the middle of the handles.



How can Hannah double the turning effect of the wire cutters, and double the force on the wire?

For each statement, tick (✓) **one** column to show what you think*.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | Squeeze with the same force, close to the pivot. |  |  |  |  |
| **B** | Squeeze with twice the force, in the middle of the handle. |  |  |  |  |
| **C** | Squeeze with the same force, at the tips of the handle. |  |  |  |  |
| **D** | Squeeze with twice the force, *anywhere* on the handle. |  |  |  |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Wire cutters** |

**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: | Predict the relative size of different turning effects by comparing forces applied and lengths of levers. |
| Question type: | Confidence grid |
| Key words: | force, pivot, turning effect |

**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 question**

Students should complete the confidence grid individually. This could be a pencil and paper exercise, or you could use an electronic ‘voting system’ or mini white boards and the PowerPoint presentation.

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs.

*Differentiation*

You may choose to read the questions to the class, so that everyone can focus on the science. In some situations it may be more appropriate for a teaching assistant to read for one or two students.

**Expected answers**

Statements B and C are correct.

Statements A and D are wrong.

**How to respond - what next?**

Many students will understand that squeezing twice as hard in the same place will give twice the turning effect.

Often when students use wire cutters (or scissors) to cut something that takes more effort, they simply squeeze harder and do not adjust the position of their grip. It is likely that students will not be familiar with the idea that increasing the distance of grip from the pivot increases the turning effect, and correct answers suggest a more general understanding of the idea of turning forces.

Answer D suggests students are thinking of the turning effect as a directly applied force, with the pivot simply changing the point of action. This (mis)understanding does not explain how forces can be multiplied by levers.

Answer A suggests students are looking for a pattern, but are perhaps guessing. They may have noticed that putting card closer to the pivot of a pair of scissors makes it easier to cut, but the card is on the opposite side of the pivot to the applied effort and this example is about moving only the applied force.

If students have misunderstandings about how the applied force and the length of lever combine to produce a turning effect, it can help to give students the opportunity to investigate the relationship between the perpendicular distance from the pivot and the applied force. The following BEST ‘response activity’ could be used to do that in follow-up to this diagnostic question:

* Response activity: Balance beam

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Wire cutters: <https://pixabay.com/vectors/pliers-tool-metal-cutter-1295562/>, Peter Fairhurst (UYSEG).

**References**

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