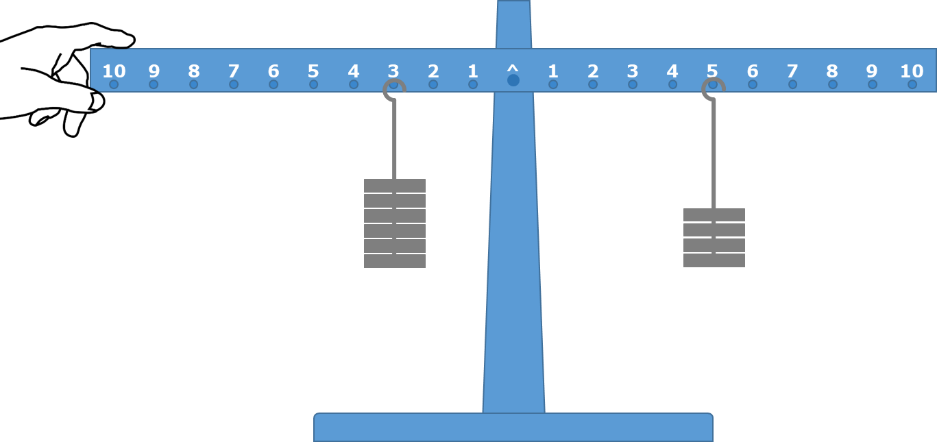
**To tip, or not to tip?**

Some weights are hanging on a balance beam.

Aiden is holding the balance level.



**a.** Which way will the balance tip when Aiden leaves go?

|  |  |  |
| --- | --- | --- |
| **A** | It will tip to the left. |  |
|  |  |  |
| **B** | It will tip to the right. |  |
|  |  |  |
| **C** | It will not tip. |  |

**b.** What is the best reason for your last answer?

|  |  |  |
| --- | --- | --- |
| **A** | There is a bigger force. |  |
|  |  |  |
| **B** | There is a longer lever. |  |
|  |  |  |
| **C** | Force **+** distance is the same on both sides. |  |
|  |  |  |
| **D** | Force **x** distance is bigger. |  |
|  |  |  |
| **E** | Force **÷** distance is bigger. |  |

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

|  |
| --- |
| **Diagnostic question** |
| **To tip, or not to tip?** |

**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 where to place different sized weights on either side of a pivoted beam, in order to make it balance. |
| Question type: | Two-tier multiple choice |
| Key words: | balance, force, lever, 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).

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.

**Ways to use this question**

Students should complete the questions 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. The follow on question will give you insights into how they are thinking and highlight specific misconceptions that some may hold.

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.

**Equipment**

For the class (optional):

* A balance beam with hanging masses as shown in the question.

**Expected answers**

a. **B**: It will tip to the right.

b. **D**: Force **x** distance is bigger.

**How to respond - what next?**

Some students are likely to get *part a* correct for the wrong reasons and some may guess at the right answer. The useful part of this question is *part b*.

In *part b*, either a bigger force (A) or a longer lever (B) would cause the beam to tip in this direction if it were the only variable to change. This question requires students to think of the force and the length of the lever together.

In this example, the force and distance do add up to the same amount on each side, but you cannot add a distance to a force (because they have different units).

D is correct because if you double the force, or if you double the distance, then force x distance will also double. This fits with students’ experience and intuition. For answer E, if the distance is doubled and the force stays the same, then force ÷ distance gives a smaller turning force for a longer lever – which is wrong.

If students have misunderstandings about how force and (perpendicular) distance (from a pivot) can be combined to calculate a turning effect, then it can help to guide the students through the equations as described above. Giving students the opportunity to test out their understanding by investigating different combinations of weights hanging from either side of a beam to make it balance can help consolidate understanding. Asking students to explain why the equation works, firstly in pairs or small groups and then individually, can also help build and consolidate understanding.

The following BEST ‘response activity’ could be used in follow-up to this diagnostic question:

* Response activity: Balance beam

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Hand: <https://pixabay.com/vectors/pointing-finger-hand-show-151637/>, 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.