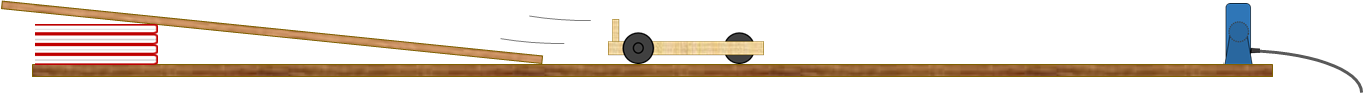
**Counter force**

A dynamics trolley speeds up as it moves down a slope.

It then rolls along a level desk and slows to a stop.

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**Predict**

When the trolley rolls along the level desk, what do you think a distance-time graph of its movement will look like?

**Explain**

Why do you think the graph will look like this?

|  |
| --- |
| **Watch the demonstration** |

**Observe**

Sketch a distance-time graph of how the trolley moves along the level desk.

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**Explain**

Were your prediction and explanation correct?

Try to improve your first explanation to explain what happens more clearly.

*Physics > Big idea PFM: Forces and motion > Topic PFM2: Moving by force > Key concept PFM2.3: Changing motion*

|  |
| --- |
| **Response activity** |
| **Counter force** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | A resultant force on an object can cause it to speed up or slow down, depending on the direction of the force. |
| Observable learning outcome: | Explain how friction and other resistive forces can act to continually reduce the speed an un-propelled object. |
| Activity type: | Predict, explain; observe, explain (PEOE) |
| Key words: | Distance-time graph, dynamics trolley, friction |

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

* Diagnostic question: Shopping trolley disaster!

**What does the research say?**

When the speed of an object is being increased, students tend to focus on the applied force that appears to be needed to get it going, and keep it going. They often think that a moving object *has* force that keeps it moving, and which runs out when it comes to rest (Gunstone, R and Watts, 1985; Driver et al., 1994a). 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.

Instead of concentrating on the applied force, students need to think about all the forces acting and how they combine to produce the resultant force. They need to identify when it acts, when it changes and when it ceases. This involves understanding friction and the direction it acts in in order to recognise how it contributes to the resultant force (Driver et al., 1994b).

In a study (Hast and Howe, 2013), children observed a ball falling in free fall, accelerating down a ramp and rolling along a flat surface. In each case they were asked to predict whether the ball was speeding up, slowing down or travelling at a steady speed through the second half of each motion. For the accelerating balls the thirty-six 11-year-olds involved in the study made correct predictions only a little more often than they would have done by chance. They were significantly worse at predicting that the ball rolling along a horizontal surface was slowing down throughout the whole of the motion.

This activity challenges students’ misunderstanding by plotting a real-time distance-time graph that shows a trolley slowing down throughout the whole of the time a resultant force acts on it in the opposite direction to its motion.

**Ways to use this activity**

Students should complete this activity in pairs or small groups, and the focus should be on the discussions. It is through the discussions that students can check their understanding and rehearse their explanations.

To begin, each group should discuss the activity and use their scientific understanding, firstly to predict *what* they think will happen, and then to explain *why* they think they are going to be right. If students in any group cannot agree, you may be able to direct them with some careful questioning.

Students now watch a demonstration and make a sketch of the graph that is produced. If you have enough sets of motion sensors and data-loggers, this may be carried out as a class practical.

After the practical each group should be given the opportunity to change, or improve their explanation. A good way to review your students’ thinking might be through a structured class discussion. You could ask several groups for their *explanations* and put these on the whiteboard. Then ask other groups to suggest which explanation is the most accurate and the most clearly expressed, and through careful questioning work up a clear ‘class explanation’.

A useful follow up is for individual students to then write down explanations in their own words – without reference to the class explanation on the board (i.e. cover it up).

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in the each group. For example, you may choose to select a student with strong prior knowledge as a scribe, and forbid them from contributing any of their own answers. They may question the others and only write down what they have been told. This strategy encourages contributions from more members of each group.

**Equipment**

For the class:

* Dynamics trolley
* Ramp
* Pile of books (or similar) to tilt the ramp
* Motion sensor and connecting lead
* Connection to a projector via a computer to plot distance-time graphs in real time or a data-logger

**Technician notes**

The ‘step’ from the ramp to desk may need smoothing out so the trolley runs smoothly. Perhaps use card taped to the bottom of the ramp.

The trolley needs to speed up as it moves down the ramp and come to a stop approximately 1m after the bottom of the ramp, in front of the motion sensor.

Whichever type of motion sensor is used, it needs to be tested in order that settings are adjusted to obtain the best results.

It can sometimes help the motion sensor to detect the position of a trolley if a flat piece of cardboard is taped to the front of the trolley.

**Health and safety**

If this activity is carried out as a class practical there is likely to be a significant amount of movement during the activity. Ramps are heavy and awkward to manoeuvre.

Dynamics trolleys can easily be damaged if they fall onto the floor.

Practical work should be carried out in accordance with local health and safety requirements, guidance from manufacturers and suppliers, and guidance available from CLEAPSS.

**Expected answers**



* Friction is the main force acting on the trolley and acts in the opposite direction to its motion
* Friction makes the trolley slow down.
* The trolley gets slower and slower until it stops, so the line on the graph goes down less and less each second.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

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