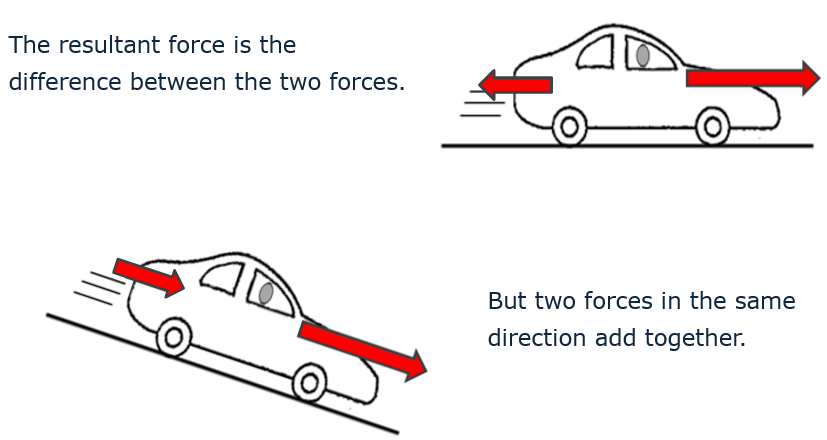
**How much is left over?**



Work out the resultant force on each toy car.

Link each car to the size and direction of the resultant force on it.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Forces on the car |  | Size of force |  | Direction of force |
| ⚫ |  | * 100 N ⚫ |  | * - - - |
| * 80 N ⚫ |
| ⚫ |
| * 60 N ⚫ | * forwards |
| ⚫ | * 40 N ⚫ |
| * 20 N ⚫ | * backwards |
| ⚫ |
| * 0 N ⚫ |

*Physics > Big idea PFM: Forces and motion > Topic PFM1: Forces > Key concept PFM1.3: Balanced and unbalanced forces*

|  |
| --- |
| **Diagnostic question** |
| **How much is left over?** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | The resultant force is the sum of the forces acting on the object, taking into account their direction. If there is no resultant force, the forces are balanced. Unbalanced forces change the speed, direction and/or shape of an object. |
| Observable learning outcome: | * Calculate the size and direction of the resultant force of two forces acting along the same straight line |
| Question type: | Diagnostic, linking ideas |
| Key words: | Resultant force, Newton, direction |

**What does the research say?**

In *The language of mathematics in science* (2016), Boohan notes that a key difference between calculations in mathematics and science is that in science the numbers we calculate with most often have a *unit* as well as a number. Students need to pay attention to the manipulation of not just the numbers but the units as well. Addition and subtraction of values can only be done if they are expressed in the *same* units. In these questions the units have been chosen to be the same.

Students may be tempted to use number lines of positive and negative numbers to combine the forces. When forces are in opposite directions it is simpler to take the smaller force from the larger and to consider the direction separately. This approach can help to clarify the idea that forces have *both* size and direction.

This question gives students the opportunity to consolidate their understanding of balanced and unbalanced forces by calculating and describing resultant forces.

**Ways to use this question**

This task is intended for discussion in pairs or small groups. It is best done as a pencil and paper exercise.

Students should look at the information and follow the instructions on the worksheet. 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 report back to the class.

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 the 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.

NB in any class, small group discussions typically improve over time and a persistence with this strategy is often very successful in the medium to long term.

Some students, who find this mathematics very straightforward, could be challenged with examples involving both N and kN.

**Expected answers**

1. 80 N forwards
2. 100 N backwards
3. 40 N forwards
4. 0 N -

**How to respond - what next?**

The challenge for students is to work out which number to add or subtract from the other. It is often helpful to support a student through to the correct answer with a series of careful prompts. Done in a supportive and constructive way, and as part of a class discussion, this allows other students to reflect on their own strategies too.

In these questions you might start by asking the student to identify the biggest force, and then to suggest which way the resultant force will be pushing in. Asking how much less the resultant force will be than the bigger force suggests that the smaller force needs to be subtracted.

You might choose to ask the follow up question: ‘what will the effect of this resultant force be on the car?’

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

* Response activity: Calculating the resultant force

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: EPSE and UYSEG

**References**

Boohan, R. (2016) *The language of mathematics in science*, Association for Science Education, Hatfield, England.