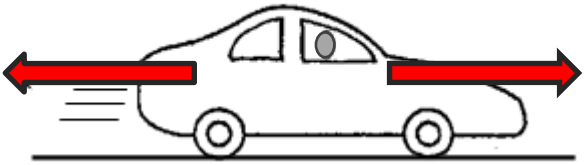
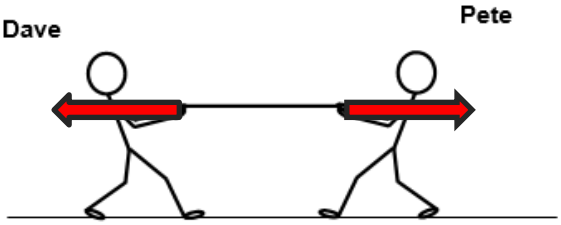
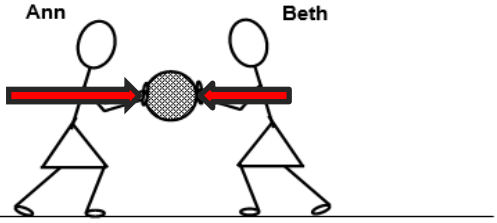
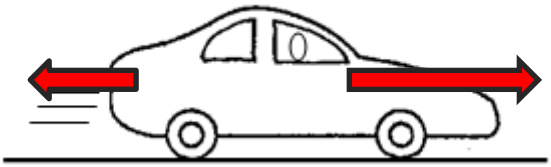
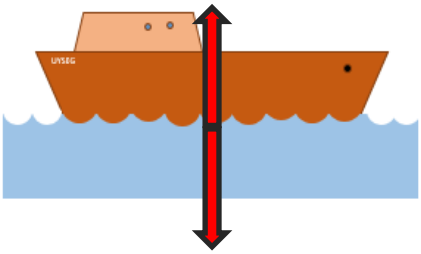
Balanced or unbalanced?

Look at each pair of forces.

Are they **balanced** or **unbalanced**? Put a ring round the right answer.

1		Balanced or Unbalanced
2		Balanced or Unbalanced
3		Balanced or Unbalanced
4		Balanced or Unbalanced
5		Balanced or Unbalanced

Diagnostic question
Balanced or unbalanced?

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:	• Identify pairs of forces that are balanced or unbalanced.
Question type:	Diagnostic, simple multiple choice
Key words:	Force, balanced, unbalanced

What does the research say?

When Erikson and Hobbs (1978) investigated students' ideas about two forces acting on the same object they found that, in a study of 32 Canadian students aged 6-14, the students appeared to think of several forces engaged in a struggle, with the bigger force dominating the weaker one. Osborne (1985) found similar thinking amongst students in New Zealand.

Equilibrium was seen by ten students, in a group of 26, as an end to this struggle after which the forces ceased to act. In fact, both forces continue to act, but there is '*not force left over to make things change*'.

This question introduces the terms *balanced* and *unbalanced* to describe pairs of forces that are acting on an object in the same straight line. This is the simplest way to combine forces and is a step towards students being able to analyse more complex groups of forces acting on an object.

Ways to use this question

Students should complete the question 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 answers to the question will show you whether students understood the concept sufficiently well to apply it correctly.

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. It can be helpful to ask '*is there any force left over?*', '*which way is the force left over pushing/pulling?*' 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

1. Balanced 2. Balanced 3. Unbalanced 4. Unbalanced 5. Balanced

How to respond - what next?

This is question is quite simple in that students identify whether opposing forces are the same size (balanced) or not (unbalanced).

If students have difficulty in identifying balanced and unbalanced forces they may not be clear about the definitions of balanced and unbalanced. It may be helpful to rehearse using the correct terms with these examples and to give the students further ones to practise.

You might choose to challenge students to identified balanced and unbalanced forces from pictures of videos, where forces are not labelled.

The size of the 'resultant' force (the force left over) is considered in the diagnostic questions: '*Resultant force'* and '*How much is left over?'*

The effects of balanced and unbalanced forces are considered in the diagnostic questions: *'What happens next?'* and '*What changes?'*

Acknowledgments

Developed by Peter Fairhurst (UYSEG).

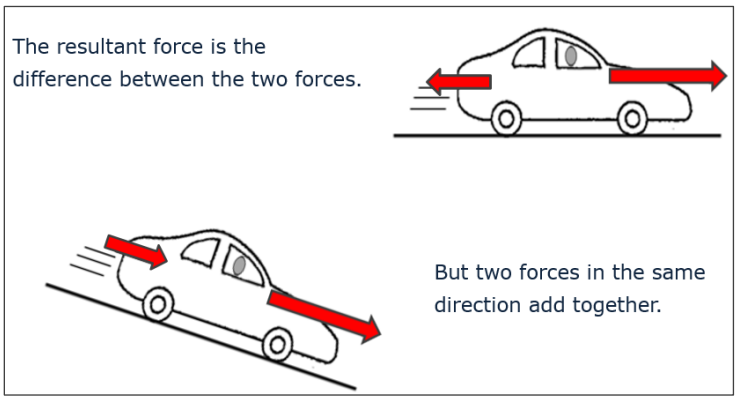
Images: EPSE and UYSEG

References

Erickson, G. and Hobbs, E. (1978) 'The developmental study of student beliefs about force concepts', Paper presented to the 1978 Annual Convention of the Canadian Society for the Study of Education. 2 June, London, Ontario, Canada.

Osborne, R. (1985) 'Building on children's intuitive ideas', in Osborne, R. and Freyberg, P., *Learning in Science,* Heinemann, Aukland, New Zealand.

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
120 N  200 N •	• 100 N •	• - - -
320 N  220 N •	• 80 N •	
	• 60 N •	• forwards
160 N  200 N •	• 40 N •	
	• 20 N •	
160 N  160 N •	• 0 N •	• backwards

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.