Make it stop!

Teacher notes

Why use this resource?

Given a particle moving under a system of forces, students are asked to add a further force to bring the particle to rest at a specified time. In doing this, students will combine various ideas about vectors with ideas from kinematics and Newton's laws of motion. As an alternative, students may choose to solve the problems using momentum and impulse. To reflect on the effect of the extra force, students are also asked to describe the motion once this extra force is applied and compare it with what would have happened if it had not been applied.

Although these problems are not set in a context, there are still opportunities to estimate and think about whether a solution is sensible.

Preparation

Copies of the problem sheet may be helpful, so that students can add to the diagrams given.

Possible approaches

It may be helpful to ask students to start by looking at the diagrams and think about what questions they have. Some of these may relate to points mentioned under the Assumptions and interpretations toggle button, but there may also be questions such as When is the extra force applied? or Does it matter where it stops? These questions could be shared in a class discussion, but do not necessarily need to be resolved at this stage, as students may resolve them for themselves as they work on the task.

The follow-up question asks students describe the behaviour of the particle when the extra force is acting on it, and compare this with what would have happened if the extra force had not been applied. Students may choose to find equations for the velocity or position vector of the particle, but they should also be encouraged to visualise and sketch the behaviour. Two GeoGebra apps have been included in the Solution section to support this.

Encourage students to relate their algebraic work to the mechanical principles they are applying. Writing up and swapping solutions, or talking another student through their approach could be useful activities to reinforce this.

Situation A has been separated from the others to encourage students to attempt the follow-up question before moving on to another situation.

Situations B, C, and D can be attempted in any order, or could be shared around within a group, offering opportunities for students to compare their approaches. Once students have tackled their own problem, they could look at another to see how their approach could be adapted.

Key questions

- If a particle is moving with a certain velocity, what do you need to do to bring it to (instantaneous) rest?
- What if you want to bring it to rest at a specified time?
- Could you sketch a force (or its components) on the diagram that could bring the particle to rest?
- What effects will the given forces have on the motion of the particle?
- How does the direction of the initial velocity affect the force that you need to add?
- What could be convenient directions for resolving the forces? (For example, two of the given forces in part D are perpendicular.)

Possible support

The key questions could help to support students who are trying to find a way into the problem. It may also be helpful to ask students to discuss how the particle would behave if no extra force is applied, as this may help them to find an approach to solving the problem.

It will be important for students to appreciate that a particle can be moving in one direction, but accelerating in a different (possibly perpendicular) direction. Resolving motion and forces into perpendicular components may therefore be helpful.

Students may wonder why the problem refers to the particle being brought to rest *instantaneously*. As well as discussing what the word means, this would be an opportunity to encourage them to think about the follow-up question.

Possible extension

Students could be asked to try alternative approaches to the problems. As vector thinking develops, students may notice that they can break the problems down in a different order, e.g. they could start by ignoring the given forces and add a force to bring the particle to rest, and then compensate for the existing forces. This is related to the vector triangle approach to situation B and more generally to frames of reference. What happens if they take this approach to situation D?

Further questions students might like to work on include

- How would answers have been different if the extra force had been applied 1 second later?

- What if you had to make the particle stop at a specific point, rather than at a specific time?