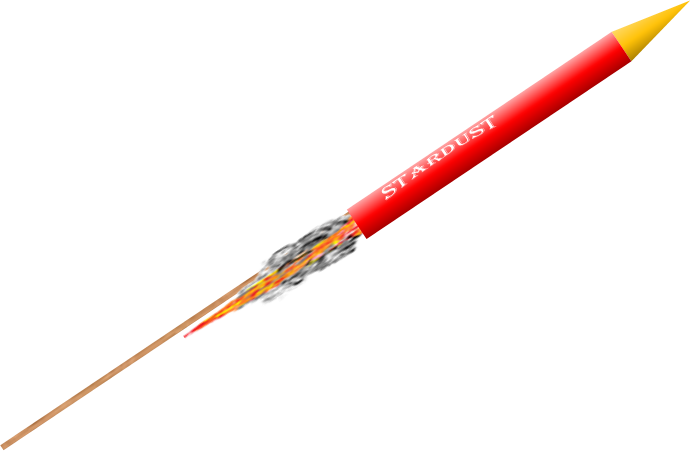
**Rocketing up**

A firework is shot up into the sky.

The gunpowder burns to produce a steady force.

As the gunpowder burns, the firework loses mass.

Some students are discussing what happens to the firework.

**Marcus:** The steady forward force makes it accelerate at a steady rate.

**Paige:** Air resistance increases as it speeds up.

**Oskar:** The force pushing it forward gets bigger as it loses mass.

**Nadia:** The resultant force increases its acceleration as it loses mass.

**Luka:** The force of gravity on the firework stays the same.

**To answer**

1. Who is definitely right about the firework?
2. Who is definitely wrong about the firework?
3. How would you describe what happens to the firework and why?

|  |  |
| --- | --- |
| Cards for  **Rocketing up** | **Luka:** The force of gravity on the firework stays the same. |
| **Marcus:** The steady forward force makes it accelerate at a steady rate. | **Nadia:** The resultant force increases its acceleration as it loses mass. |
| **Oskar:** The force pushing it forward gets bigger as it loses mass. | **Paige:** Air resistance increases as it speeds up. |

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| Cards for  **Rocketing up** | **Luka:** The force of gravity on the firework stays the same. |
| **Marcus:** The steady forward force makes it accelerate at a steady rate. | **Nadia:** The resultant force increases its acceleration as it loses mass. |
| **Oskar:** The force pushing it forward gets bigger as it loses mass. | **Paige:** Air resistance increases as it speeds up. |

*Physics > Big idea PFM: Forces and motion > Topic PFM6: Forces make things change > Key concept PFM6.2: Force, mass and acceleration*

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| **Response activity** |
| **Rocketing up** |

**Overview**

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| Learning focus: | The acceleration of an object is proportional to the resultant force acting on it and inversely proportional to its mass. An object accelerates in the direction of the resultant force acting on it. |
| Observable learning outcome: | Apply an understanding of F = m x a for a changing mass. |
| Activity type: | Talking heads |
| Key words: | Force, mass, acceleration, air resistance, drag |

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| **B** | **BRIDGING**  This activity explores ideas that are usually taught at age 16-19, to build a bridge to later stages of learning. |

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

* Diagnostic question: Accelerating ball
* Diagnostic question: Stopping in mid-air

**What does the research say?**

When thinking about forces and motion, students treat motion in a horizontal plane and motion in a vertical plane differently (Lemmer, 2013). Some students do not see weight as a force, believing that gravity is the natural tendency of things to fall. Students may believe that when objects rise and fall in a gravitational field, upward and downward motions need to be explained differently (Twigger et al., 1994).

**Ways to use this activity**

This task is intended for discussion in pairs or small groups. It can be done as a pencil and paper exercise or projected onto a screen.

Students should read the statements and follow the instructions on either the worksheet or the PowerPoint. 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.

Feedback from each group can be used, with careful teacher questioning, to bring out a clear description or explanation of the science.

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in 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.

**Expected answers**

1. Paige is definitely right. (Nadia might be right, and she might be wrong.)

As the firework moves more quickly it pushes air out of the way at a faster rate and the air pushes back on the firework with a greater force.

2. Luka, Marcus and Oskar are wrong.

The force of gravity on the firework is equal to its weight which is decreasing. Students may be confused with the gravitational field strength, g, which does stay the same. This describes the force *per kilogram* acting on an object.

The steady forwards force of the firework, combined with increasing air resistance means that the resultant force on the firework is changing. This results in a changing acceleration.

The forwards force is described in the question as a steady force and can be assumed not to change.

3. As the firework increases speed air resistance increases and its weight decreases.

If it loses weight faster than the air resistance increases, then the resultant force pushing it forwards will increase and it will accelerate faster and faster until the fuel runs out.

If air resistance increases faster than it loses weight, then the resultant force pushing it forwards will decrease and it will accelerate less and less quickly until the fuel runs out.

When the fuel runs out, air resistance will slow the firework down and its remaining weight will pull it towards the ground.

**Acknowledgments**

Developed by Simon Carson (UYSEG) and Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

Lemmer, M. (2013). Nature, Cause and Effect of Students' Intuitive Conceptions Regarding Changes in Velocity. *International Journal of Science Education,* 35(2)**,** 239-261.

Twigger, D., et al. (1994). The conception of force and motion of students aged between 10 and 15 years: an interview study designed to guide instruction. *International Journal of Science Education,* 16(2)**,** 215-229.