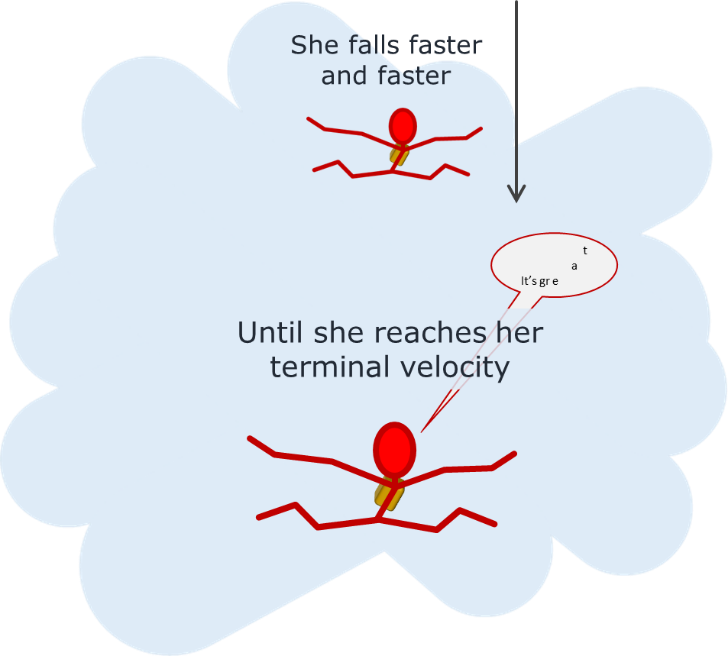
**Free-fall**



Eve jumps out of a plane!!!

(She is wearing a parachute.)

Some students are discussing why Eve reaches a top speed.

**Jake:** There are no forces on Eve when she stops accelerating because F=ma.

**Poppy:** She stops accelerating because the air pushes equally on her in all directions.

**Nadia:** The faster Eve gets, the more the air resistance pushes up on her.

**Lexie:** She is weightless because all the forces cancel out.

**Umar:** She stops accelerating when her weight is equal to the drag and F=0.

**To answer**

1. Who is right about why Eve reaches a top speed?
   * *Explain your answer*

**2.** Who is wrong about why Eve reaches a top speed?

* + *What would you say to help them understand?*

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| --- | --- |
| Cards for  **Free-fall** | **Jake:** There are no forces on Eve when she stops accelerating because F=ma. |
| **Lexie:** She is weightless because all the forces cancel out. | **Nadia:** The faster Eve gets, the more the air resistance pushes up on her. |
| **Poppy:** She stops accelerating because the air pushes equally on her in all directions. | **Umar:** She stops accelerating when her weight is equal to the drag and F=0. |

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| Cards for  **Free-fall** | **Jake:** There are no forces on Eve when she stops accelerating because F=ma. |
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*Physics > Big idea PFM: Forces and motion > Topic PFM6: Forces make things change > Key concept PFM6.2: Force, mass and acceleration*

|  |
| --- |
| **Response activity** |
| **Free-fall** |

**Overview**

|  |  |
| --- | --- |
| 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: | Use the equation F = m x a to determine and explain the motion of falling objects. |
| Activity type: | Talking heads |
| Key words: | Force, mass, acceleration, air resistance, drag |

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. Nadia and Umar are correct.

As Eve fall faster, she pushes air out of the way at a faster rate and the air pushes her up with an increasing force.

When she is going so fast that the force of air resistance is as big as the force of gravity, she stops accelerating and travels at a steady top speed. (No force is left over to speed her up or to slow her down.)

2. Jake, Lexie and Poppy are wrong.

When Eve stops accelerating, the resultant force acting on her is zero, but this is because the forces of air resistance and gravity are the same size and acting on Eve in opposite directions.

She is not weightless. If she did not have a weight, the force of air resistance would slow her down.

When Eve is not falling, the air pushes on her equally in all directions, but as she is falling through the air, the air is pushing her upwards with more force than it is pushing in other directions.

**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.