

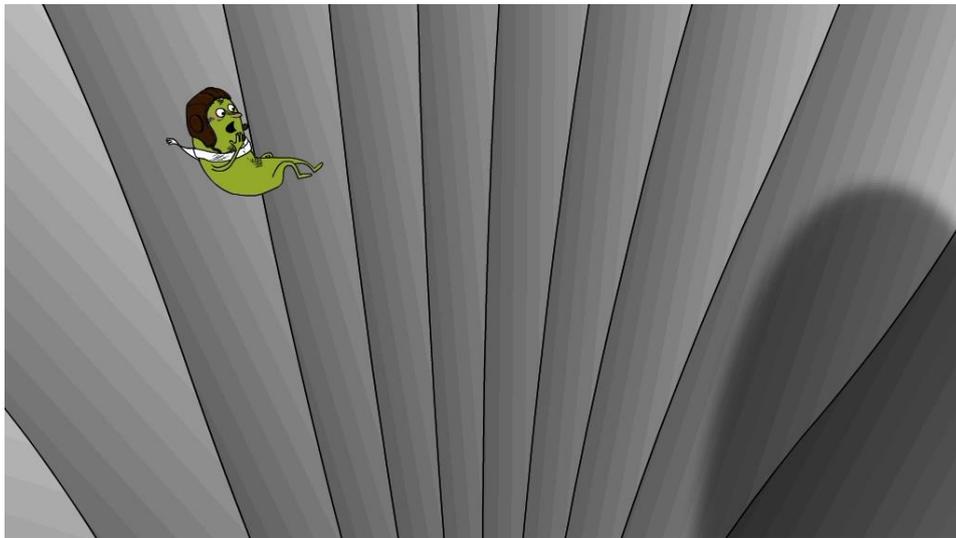
Notes for teachers

At a glance

In this activity, students learn about heat transfer from jet engine turbine blades. The blades reach temperatures as high as 1000 °C. How do the blades cool, and how do scientists measure the rate of cooling at such high temperatures?

In this activity students design and carry out an investigation to answer the question *How much faster does an object cool when surrounded by moving air?* If available, they use liquid crystal forehead thermometers to compare cooling rates.

An additional activity provides guidance for students to find out the answers to one or more research questions about turbine cooling systems, as well as jet engines in general.



Learning Outcome

- Students learn how to compare the rates of cooling of an object when surrounded by cooling air, and when not surrounded by cooling air.

Each pair of students will need

- 1 copy of the pupil worksheet and group challenge sheet
- 1 copy of the peer assessment sheet
- Help sheet (optional)
- Access to an electronic version of the image bank Presentation file (optional)
- Liquid crystal forehead thermometer, or ordinary alcohol lab thermometer if not available
- Warm object eg beaker of warm water, or metal block warmed in hot water
- Source of moving air, such as fan or hair dryer on cold setting
- Timer
- Access to the Internet and/or text books that refer to jet engines
- Poster-making equipment (optional)

Web link

Rolls Royce journey through a jet engine (referred to in the Pupil sheets)

http://www.rolls-royce.com/interactive_games/journey03/

Possible Lesson Activities

1. Starter activity

- Show the animation 'Jet plight' to the class. www.oxfordsparks.net/jet
- Repeat the viewing, focusing on the section from 0:44 to 1:25, which explains that a great deal of jet engine research focuses on keeping the jet engine cool, and describes the functions of jet engine components.

2. Main activity

- Allow students time to read the first page of the pupil worksheet, which emphasizes key points from the animation and introduces the investigation.
- Student groups follow the guidance on the *Group challenge* page of the pupil worksheet to design and carry out an investigation to answer the question *How much faster does an object cool when surrounded by moving air?* If using liquid crystal forehead thermometers, they can only measure the rate of cooling over a temperature range between around 40 °C to 34 °C. It is simpler to use a conventional lab thermometer to ensure water is supplied at a suitable starting temperature. It is not straightforward to read the temperature on a liquid crystal thermometer – the temperature of the object is given by the middle coloured bar. The purpose of using liquid crystal thermometers is to model the temperature measuring technique developed by Oxford researchers – of course they use liquid crystals that show temperature changes at the temperatures of turbine blades. A help sheet is available on which students can record their findings.
- Students can then complete one or more of the further research tasks on the *Group challenge* page of the worksheet. The questions are ramped, so the first question is suitable for all students, and the final question is designed to challenge the highest attaining students.
- Students follow the guidance on the *Group challenge* sheet to plan how to communicate their findings to another group.

3. Plenary

- This involves students communicating their findings to another group.
- Groups use the peer assessment sheet to guide them in assessing the work of another group.
- Allow time for groups to study the assessment sheet for their own work.
- If you wish, show the animation again.

Further suggestions

Use thermochromic paint (available from Amazon, as well as other suppliers) to demonstrate the cooling of a hot object of your choice.