

## Pupil worksheet

### Jet engine

A jet engine pushes a huge mass flow of gas backwards. An equal but opposite force, called thrust, pushes the aeroplane forwards.



A jet engine includes a turbine. The turbine extracts energy from the hot gases that flow over it. It converts this energy to useful work.

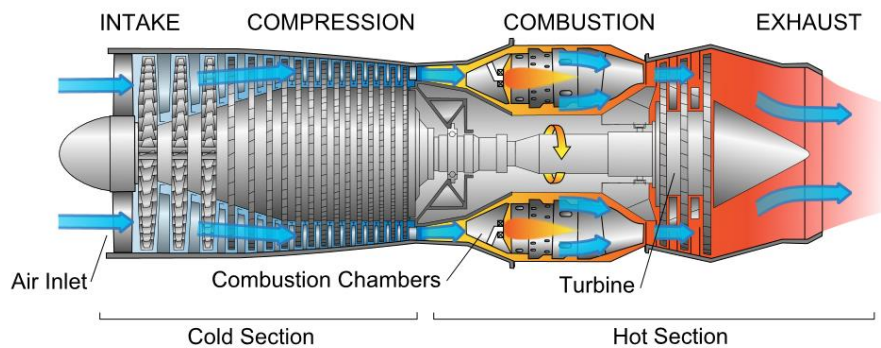
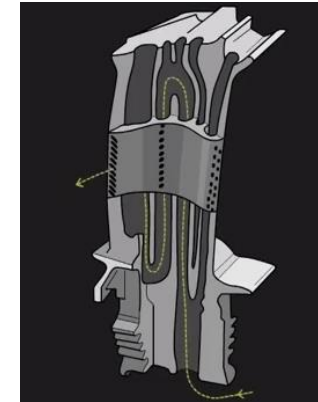


Image: Jeff Dahl, Wikimedia Commons

Turbine blades get very hot. Their temperature can reach 1000 °C. Moving air cools the hot blades. The air enters a system of holes inside each blade. Air seeps out of the holes. This results in a film of cooler air around the blades.



Engineers test different turbine blade designs. They want to find the best way of using air to cool them quickly.

How do engineers collect data to compare their designs? They need to measure turbine blade temperatures, but normal thermometers do not work at such high temperatures. For this reason, scientists often experiment at lower temperatures so that they can make more detailed measurements.

Oxford engineers have pioneered the use of liquid crystal thermometers to measure temperatures in these experiments. They work like a forehead thermometer, but measure temperatures over a much greater range.



### Group challenge

#### Investigation

Design and carry out an investigation to answer the question *How much faster does an object cool when surrounded by moving air?* If possible, use a liquid crystal thermometer to measure temperature.

#### Hints

- Your object could be a beaker of water, or a block of warm metal.
- Look at the range of your thermometer. If it is a liquid crystal forehead thermometer, its range may be only 34 °C to 40 °C. You will only be able to measure temperatures within this range.

#### Safety

- Wear eye protection
- Take care when handling hot objects

#### Further research

Choose one or two of the questions below, or make up your own. Use text books or the Internet to research answers to these questions.

- Is heat transferred from the turbine blade by conduction, convection or radiation, or by a combination of these processes? Use diagrams to illustrate your answer.

- What are the differences between liquid crystal thermometers used to measure body temperature and liquid crystal thermometers used to measure turbine temperature?
- What are the roles of the compressor, combustor and turbine in a jet engine? Search the Internet for '*Rolls Royce journey through a jet engine*' to find out. Your teacher has the web site address.
- What are the similarities and differences between a jet engine turbine cooling system and a car engine cooling system? Search the Internet for '*How stuff works car cooling systems*' to find out.

#### Communicating your findings

Tell another group what you have found out about turbine cooling and jet engines.

Follow these steps:

- 1 Choose your communication tool – poster, presentation, drama, video storyboard or written account.
- 2 Decide what you want to tell the other group.
- 3 Work out what needs to be done, and divide the tasks between the members of your group.

If you wish, choose pictures from the Image Bank PowerPoint to illustrate your work.

Use the Peer Assessment sheet to help you make sure you include everything.

### Peer assessment

Look at – or listen to – the work produced by another group. Then complete this form.

Question	How clearly did they answer this question? 1 = not clear 3 = very clear
How much faster does an object cool when surrounded by moving air?	
Research question 1 ..... .....	
Research question 1 ..... .....	

1. What were the two best things about the other group's work?



2. Suggest one improvement.

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#### 4. Help sheet

<b>Investigation question</b>																				
<b>Investigation diagram</b>																				
<p><b>Investigation results</b></p> <table border="1" style="width: 100%; border-collapse: collapse; margin: 10px 0;"> <thead> <tr> <th rowspan="2" style="width: 15%;">Time (minutes)</th> <th colspan="2" style="text-align: center;">Temperature (°C)</th> </tr> <tr> <th style="width: 30%;">Without moving air</th> <th style="width: 30%;">With moving air</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> </tbody> </table>	Time (minutes)	Temperature (°C)		Without moving air	With moving air															
Time (minutes)		Temperature (°C)																		
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<b>Investigation conclusion</b>																				

Research question	Answer
First question	
Second question	