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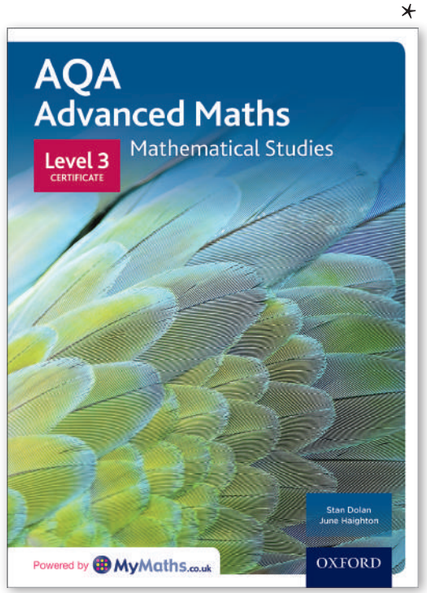

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Advanced Maths

Level 3
CERTIFICATE

Mathematical Studies

Draft sample content

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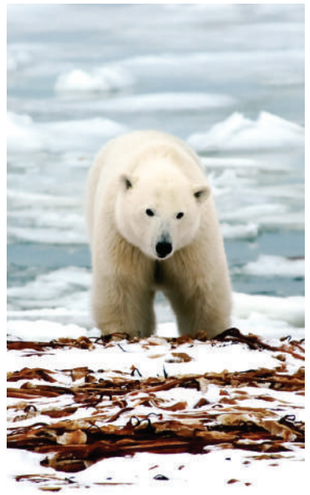
3.1 Modelling the Gulf Stream

Paper 1

You may have noticed from maps and photographs of the Earth that the British Isles are, roughly, as far north as Canada. The photograph of the polar bear shows a scene that is typical of Hudson Bay but not of the Irish Sea at a similar latitude. So, why do we have such a mild climate?



One major reason is the warm ocean current, called the Gulf Stream, flowing from Florida, across the Atlantic to Northern Europe. To find out why it has such a major effect on our climate, think about this question:

Example 1 How much warm water flows past the British Isles in the Gulf Stream every hour?

Activity

★ List the quantities that you will need to estimate to answer this question about the Gulf Stream.

★ What assumptions would you make when making these estimates?

You might be able to estimate the speed of the Gulf Stream based on your experience of currents when swimming in the sea. The accepted average speed for the Gulf Stream is about 6.4 km/h but the figure of 5 km/h is perfectly sensible and will give a good answer to the question.

One very important factor is the speed of the Gulf Stream. You could make these assumptions and estimates:

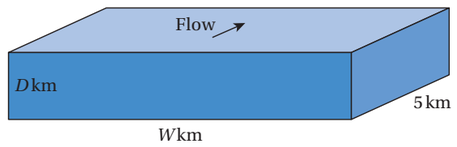
- Assume that the Gulf Stream has a constant speed all year.
- Assume that all the water in the Gulf Stream has the same speed, whether at the surface of the ocean or in the depths.
- Estimate the speed to be walking speed, 5 km/h.

Next you could model the cross-section of the Gulf Stream.

- Assume that the Gulf Stream has a rectangular cross-section.

A cuboid is an easy-to-use simplification.

Then the model for the water flowing past the British Isles in 1 hour is a cuboid like this:



An average speed of 5 km/h means that in 1 hour the water flows 5 km.

where D is the depth of the Gulf Stream and W is its width in kilometres.

Now you need to make assumptions or estimates for D and W.

- Assume that $D = 1$ and $W = 100$.

Values of half or double these would be just as sensible.

The volume of water flowing past the British Isles in 1 hour is therefore $1 \times 100 \times 5 = 500\,\text{km}^3$

Volume of cuboid $= lwh$

Convert this into cubic metres, using $1\,\text{km}^3 = 1\,000\,000\,000\,\text{m}^3$

$$500\,\text{km}^3 = 500 \times 1\,000\,000\,000\,\text{m}^3$$
$$= 500\,000\,000\,000\,\text{m}^3$$

You can find 'official' answers to questions like this on the internet. If your answer is a long way out then you should review all the assumptions you made and see if, in hindsight, some of them were unrealistic. However, remember that estimates of some quantities are disputed by experts in the subject. You are only using rough and ready methods to obtain 'ball-park' figures.

In fact the rate of flow of the Gulf Stream varies at different times and in different locations.

Activity

Research on the internet:

- the average speed, width and depth of the Gulf Stream as it passes the British Isles. Do you need to change any of the assumptions made in the example? If so, do a new calculation.
- the amount of water flowing past the British Isles in the Gulf Stream in one hour. Is the estimate of $500\,000\,000\,000\,\text{m}^3$ per hour reasonable?

★ The California current flows south along the California coast. It is approximately 40 km wide and 1 km deep. Estimate the amount of water flowing per hour.

In the Gulf Stream problem, the key to the solution was the formula

Volume of water per hour = Area of cross section × Speed

Using this simple formula meant you could split an apparently difficult problem into two much more straightforward parts:

- estimating the area of cross section
- estimating the speed.

Later in this chapter you will see many other examples of splitting up problems which appear difficult into simpler parts, in order to solve them.