

# Topical Applications of Mathematics

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## Carbon Footprint

## PUPIL TEXT

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The concept of a **carbon footprint** is highly topical. Almost everything we do in life leads to emissions of the gas, carbon dioxide ( $\text{CO}_2$ ). Although this colourless, odourless gas occurs naturally in the air, too much of it leads to the **greenhouse effect** in which heat from the sun is trapped, causing the Earth to get hotter, i.e. **global warming!**

The increased use of coal, oil and gas (fossil fuels) and changes in land use (for example, large areas of forest being destroyed) are two of the main causes of global warming.

Your carbon footprint is a measure of the impact your activities have on the environment in terms of the amount of greenhouse gases produced. It is measured in units of carbon dioxide and usually expressed in kilograms (or tonnes) of  $\text{CO}_2$ .

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### Activity 1

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*What items contribute to your carbon footprint?*

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In fact, almost every activity (apart from sleeping!) contributes. For example,

- electricity or gas used in heating, lighting and cooking
- travel by car, bus, train ship or plane.

Most governments have become very concerned about the heating up of our planet. Scientists believe that the average air temperature has risen by about  $1^\circ\text{C}$  over the last 100 years.

Although this might not seem to be catastrophic, the rate of increase is rapidly increasing so that in the next 100 years, it is expected to increase by approximately  $5^\circ\text{C}$ .

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### Activity 2

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*Find out about the Kyoto Protocol (or Agreement). Which major countries have not yet ratified this agreement?*

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The UK has signed up to and ratified the Kyoto Protocol, which came into effect in 2005. Under the terms of the Protocol, developed countries are required to reduce their carbon emissions by 5% by 2012, compared to their 1990 emissions levels.

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### Activity 3

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*In 1990, the total UK carbon emissions were estimated to be 600 000 000 tonnes and by 2005 had increased to 680 000 000 tonnes. Suggest carbon emission targets for the UK for 2006, 2007, . . . , 2012 in order for the UK to meet the requirements of the Kyoto Protocol.*

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In the UK, there has been a great deal of publicity about the issue of reducing carbon emissions by individuals (and families) as well as business and commerce.

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#### **Activity 4**

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*Have you put into practice any activities to reduce **your own** carbon emissions in your home?*

*Do you know of any changes made by **your family** to reduce carbon emissions?*

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The average person in the UK has a carbon footprint of about 10 000 kg (or 10 tonnes) a year.

The recommended carbon footprint per person is 2500 kg (or 2.5 tonnes).

#### **How do we calculate our carbon footprints?**

You can go to

<http://actonco2.direct.gov.uk/index.html>

to calculate carbon footprints.

Here we will look at just one aspect of the calculation, namely **travel**.

The following table gives estimations of the carbon emissions per km for different forms of transport.

<i>Transport</i>	<i>Carbon emissions</i> (kg per km)
Walk	0.00
Bicycle	0.00
Bus	0.09
Train	0.06
Motorbike	0.10
Car	0.21
Plane (domestic)	0.16

These are average values.

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### Activity 5

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Why do the carbon emissions for a) CAR, b) TRAIN vary?

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### Worked Example

Compare the carbon emissions for a person travelling 200 km by each of the means of transport listed in the table.

### Solution

<i>Transport</i>	<i>Carbon emissions (kg per km)</i>	<i>Total emissions</i>
Walk	0.00	0
Bicycle	0.00	0
Bus	0.09	$0.09 \times 200 = 18$
Train	0.06	$0.06 \times 200 = 12$
Motorbike	0.10	$0.10 \times 200 = 20$
Car	0.21	$0.21 \times 200 = 42$
Plane (domestic)	0.16	$0.16 \times 200 = 32$

So, apart from walking and cycling (which would be hard work for a distance of 200 km!), the order of the most carbon efficient mode of transport is

*Train, Bus, Motorbike, Plane, Car*

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### Activity 6

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Why is it not always possible to travel by train?

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One of the most problematic aspects of this model is that the carbon emissions are not as precise as the figures indicate. For example, for CARS, emissions vary according to the engine size and type of car (petrol, diesel) and the number of passengers.

The following table gives more detailed information.

<i>Type of car</i>	<i>Carbon emissions</i> (kg per km)
Small, petrol car (up to 1.4 litres)	0.18
Medium, petrol car (1.4 – 2.0 litres)	0.22
Large, petrol car (above 2.0 litres)	0.30
Small, diesel car (up to 1.7 litres)	0.15
Medium, diesel car (1.7 – 2.0 litres)	0.19
Large, diesel car (over 2.0 litres)	0.26

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**Activity 7**

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*Work out the carbon emissions for each type of car in the table above for a 200 km journey.*

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Clearly, a small diesel car is most ‘green’ and a large petrol car is the least efficient when only one person is travelling. However, a large petrol car carrying 2 people is more efficient in emissions terms than a small petrol car with just a driver!

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**Activity 8**

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*How can governments encourage motorists to buy cars that have low carbon emissions?*

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Mathematics cannot solve our problems but knowing how carbon emissions can be calculated does at least provide us with the knowledge to make informed lifestyle choices.

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**Activity 9**

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*It has been suggested that non-essential plane travel (that is, for holidays, etc.) could be limited by allowing each ADULT to use, for example, 500 kg of carbon emissions per year for plane travel. Anyone exceeding this amount could be fined.*

Where could you go for your holiday (or holidays) by plane, keeping in line with the 500 kg of carbon emissions allowable?

You will need to use this information:

<b>AIR TRAVEL</b>	<b>Carbon emissions</b> (kg per km)
Long haul international (beyond Europe)	0.1056
Short haul international (inside Europe)	0.1304
Domestic (within UK)	0.1580

and you will also need to know the distances between destinations. The website

<http://www.geobytes.com/CityDistanceTool.htm?loadpage>

can be used to help you calculate distances.

Data Sheet 4 shows approximate distances from 3 UK airports to some possible holiday destinations.

Don't forget that your calculations will have to include **return flights!**

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