# Lesson 4: Escape

## Narrative

Four of the team were nearly caught by the guards but they have escaped into the forest. They are close to a point where a dilapidated rope bridge is suspended across a muddy river infested with crocodiles. In the confusion, they have lost all but one of their torches. They are suffering from various degrees of exhaustion and are hiding in the dense undergrowth waiting for first light. One member of the group uses his camera to film the other three as more evidence for the UN. A radio message from another group informs them that they must get across the bridge to the clearing where a helicopter can evacuate them – but they must hurry, the guards are only 15 minutes behind them! The group cannot leave it any longer. They must cross the river in the dark, using the bridge.

## Problems

### Main problem

The rope bridge can hold only two people. It is dark and dangerous, so the torch must be used by whoever is crossing. The group leader can cross in 1 minute, but the other three will take 2 minutes, 5 minutes, and 8 minutes respectively. When two people cross together, they must move at the slower person's pace. Can all four of them get across the bridge in 15 minutes or less? And how can the group use their mobile phones to send their plan to the other environmentalists who are following?

**Supplementary or homework problems** (optional)

**1** Another group of four has reached the river. They come across an old canoe with a paddle but the canoe cannot carry more than 100 kg. The leader weighs 90 kg and the others weigh 80kg, 55kg and 45 kg. They have a single 20 kg pack of equipment which contains their gear and their UN report. How can they get across as quickly as possible?

**2** Having escaped from the rainforest and out of the clutches of Log Inc, the team must now return to UK. How will they get home? Which method of transport will they use to minimise their carbon footprint?

## Skills required

In this lesson pupils will:

- identify the necessary information to solve a mathematical problem
- try out and compare mathematical representations
- use logical argument to establish the truth of a situation
- draw simple conclusions of their own and give an explanation of their reasoning
- check results, considering whether they are reasonable.

## Rainforest resources

**4.1** Video clip: (1 minute): It is dark. The group pauses to gather breath – the fourth member of the group valiantly continues to film. A walkie-talkie message comes through – the guards are close behind and the group needs to get over the rope bridge and to safety.

**4.2** A4 resource sheet of the main problem and a supplementary one about getting across the river (print one copy per pair, and one copy per pupil if needed for homework)

**4.3** Final video clip: (1 minute 20 seconds): A helicopter is circling around and the team is running through forest. 'Heavies' appear on the horizon. The team runs into a clearing and escapes in the nick of time!

**4.4** A4 resource sheet of an additional problem (print one copy per pair, and one copy per pupil if also needed for homework)

**4.5** Slide with an outline map of the world showing the relative locations of Venezuela and the UK HQ

## Other resources

For pupils: pencils and erasers, and scraps of paper which can be labelled **A**, **B**, **C** and **D** with the times taken to cross the river.

## Main activity 1

Begin the final stage of the mission. Play **Resource 4.1**, a 1-minute video clip.

Give out copies of **Resource 4.2** for groups to work on the first main problem. If they get stuck, feed them at intervals with prompts such as:

- Would it help to draw a diagram showing the two river banks and use scraps of paper to represent the people?
- Which member of the group should make the most crossings?
- Which two people should cross together so that the crossing time of the faster one is discounted and is not included in the total time?

## Differentiation

Any groups that may need a simpler problem, or groups that finish the first problem quickly, could try the supplementary problem on **Resource 4.2**.

## Main activity 2

Take brief feedback on the river crossing problems, then play **Resource 4.3**, the final video clip (80 seconds) showing the success of the mission: the helicopter lands, picks up the team and takes off again, all just in time.

If time allows, or as an alternative to the river crossing problems, give out **Resource 4.4**, the additional problem. Data is provided to allow pupils to plan their journey home from Caracas, Venezuela to the UK. The sources of information used for this resource are:

http://www.carbonfund.org/site/pages/carbon_calculators/category/assumptions
http://www.epa.gov/chp/documents/hotel_casino_analysis.pdf
http://docs.wri.org/wri_co2comm_2002_commuting_protected.xls

Use **Resource 4.5**, a slide showing an outline map of the world, to check that pupils know the location of Venezuela and understand the options that are available. Also point out that for every 1200 km of road travel, they will need an overnight hotel stop.

Give the groups an opportunity to talk through some of the issues and understand the problem. Emphasise that you will be asking them to present a reasoned and costed method to travel home, based on the data given.

This task could be time-consuming task if pupils considered every possibility. One approach would be to ask the groups to discuss travel possibilities, then to share their ideas in a plenary. The class could then discuss which possibilities to pursue and one or two groups could calculate the $CO_2$ footprint for each selected possibility. Teams could present their findings and together select the preferred method of travel. This approach would minimise duplication of calculations while engaging all pupils in the possibilities. It would also allow all pupils to 'end the case study feeling a real sense of achievement'.

**Review**

Take feedback on the progress the groups have made in planning their journey home.

Finish the case study by explaining that in real life people are often required to work in teams on problems that involve mathematics, just as would happen if there really were an undercover mission to find out more about illegal logging activities.

**Optional homework**

Pupils could either do the supplementary problem if they have not done it in class, or they could continue to refine their planning of their journey home.

# Solutions: Lesson 4

## Main problem on Resource 4.2

**1** Assume that the team leader is **A** (1 min) and the others are **B** (2 min), **C** (5 min) and **D** (8 min).

An obvious first idea is that the time to return the torch to the people waiting to cross should be minimised. This strategy makes A the torch bearer, shuttling each person across the bridge in turn.

| Elapsed time | Start side | Action | Other side |
|---|---|---|---|
| 0 minutes | ABCD | | |
| 2 minutes | CD | A and B cross, taking 2 minutes | AB |
| 3 minutes | ACD | A returns, taking 1 minute | B |
| 8 minutes | D | A and C cross, taking 5 minutes | ABC |
| 9 minutes | AD | A returns, taking 1 minute | BC |
| 17 minutes | | A and D cross, taking 8 minutes | ABCD |

This strategy takes 17 minutes, which is too long.

If the two slowest people cross individually, this wastes time. To solve the problem, they need to cross together. For example:

| Elapsed time | Start side | Action | Other side |
|---|---|---|---|
| 0 minutes | ABCD | | |
| 2 minutes | CD | A and B cross, taking 2 minutes | AB |
| 3 minutes | ACD | A returns, taking 1 minute | B |
| 11 minutes | A | C and D cross, taking 8 minutes | BCD |
| 13 minutes | AB | B returns, taking 2 minutes | CD |
| 15 minutes | | A and B cross, taking 2 minutes | ABCD |

This strategy takes exactly 15 minutes.
The return crossings made by A and B could be interchanged.

## Supplementary or homework problem on Resource 4.2

Assume the team are:
A (90 kg), B (80 kg), C (55 kg) and D (45 kg) and the rucksack is R (20 kg).

Variations on the solution on the right are possible but they all result in 9 crossings, five across and four back.

| Start side | Action | Weight | Finish side |
|---|---|---|---|
| ABCD + R | Start | | |
| AB + R | C and D cross | 100 kg | CD |
| ABD + R | D returns | 45 kg | C |
| BD + R | A crosses | 90 kg | AC |
| BCD + R | C returns | 55 kg | A |
| B + R | C and D cross | 100 kg | ACD |
| BD + R | D returns | 45 kg | AC |
| D | B crosses with R | 100 kg | ABC + R |
| CD | C returns | 55 kg | AB + R |
| | C and D cross | 100 kg | ABCD + R |

## Additional problems 4.4

Assuming that 'UK HQ' is in London …, here are two possible options that pupils could use in their arguments.

- **Option A:**

  By air direct from Caracas to London:

  Caracas to London ≈ 4690 miles

  0.18 kg of $CO_2$ per mile → 844.2 kg of $CO_2$

  for 4 people → 3376.8 kg of $CO_2$

- **Option B:**

  By air from Caracas to Miami

  By sea from Miami to Southampton

  By bus from Southampton to London

  By air Caracas to Miami ≈ 1371 miles

  0.18 kg of $CO_2$ per mile → 246.78 kg of $CO_2$

  for 4 people → 987.12 kg of $CO_2$

  By sea Miami to Southampton = 3882 sea miles

  0.43 kg of $CO_2$ per sea mile → 1669 kg of $CO_2$

  for 4 people → 6676 kg of $CO_2$

  By bus Southampton to London = 111 miles

  0.08 kg $CO_2$ per km → 8.88 kg

  for 4 people → 35.52 kg

  **Total for the journey** = 987.12 + 6676 + 35.52

  = 7698.64 kg of $CO_2$

These are not the only possibilities.

Pupils might think that air travel gives a larger carbon footprint. Certainly figures would suggest that where it is possible rail travel has a lower carbon footprint than short haul air travel but where rail or road travel is not possible (e.g. for long distances across oceans), air travel is a better alternative than sea travel.