

Lesson 4: Emergency plans

Narrative

The crowds are in and moving to Torbury Fields, the flat part of the site around the main Torbury Stage. It's getting dark and there's a big buzz in the air. Laser beams cut across the sky and The Prime Numbers, the headline act, have been spotted arriving on site. In the excitement there are some mishaps. Some of the festival goers are getting rowdy and are threatening to storm the stage whilst some gatecrashers try to climb over the boundary wall. Mavis knows that it is vital that the star band and audience are safe at all times. She again calls in the FSS. This time she asks them to check arrangements for surveying Torbury Fields and watching for flash points, and for evacuating the band in the event of an emergency.

Problems

Main challenges

- 1 The festival's insurance company have heard rumours about gatecrashers trying to climb over the walls. They have demanded that security staff must be able to see at least 85% of Torbury Fields from observation points. One observation tower with a swivelling telescope has already been erected to spot potential intruders. The squad teams check how much of the Torbury Fields area can be observed by the telescope. They recommend where to erect more towers in order to see at least 85%.
- 2 The lead singer of The Prime Numbers, Zak, will need an escape route if the crowd gets too enthusiastic and storms the stage. In the event of an emergency a helicopter will be on hand but will not be able to land because of all the mud from the floods and the crowds of people. The teams need to determine the spot where the lead singer should stand in order to be winched to safety, and where to position the spotlights to be clear of the rotor blades, allowing for a margin of error.

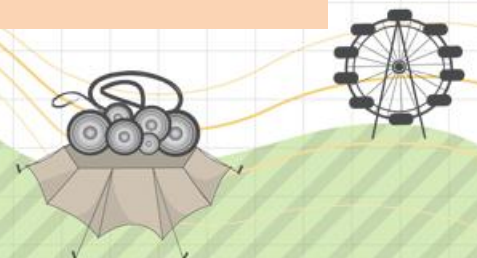
Further problems or homework (optional)

- 1 Torbury fields are flat ground. The Dance Village includes a dance tent which is a square measuring 200 m by 200 m. The walls of the tent are 4 m high and, at its highest point, the ridge roof is 6 m above the ground. The security staff need to be able to see all of the exterior perimeter fence of the Dance Village over the dance tent. The observation tower, which has to be less than 15 m high, has a swivelling telescope. The teams must decide where to position the dance tent in the Dance Village.
- 2 The teams must also decide how high the observation tower needs to be.

Skills required

In this lesson pupils will need to:

- interpret and make scale drawings
- convert between units of measurement and make sensible estimates of measures in everyday situations
- calculate areas of plane shapes, including circles
- calculate percentages of quantities



- use straight edge and compasses to construct perpendicular bisectors of line segments and bisectors of angle
- determine the locus of an object moving according to a rule.

Torbury resources

- 4.1** Video clip: (1'09") The crowds are gathering for the headlining act. Muddy revellers are clearly excited. Security are erecting a scaffolding surveillance tower, while Mavis briefs the FSS by telephone on the requirements for site surveillance and the checks she wants made.
- 4.2** A4 resource sheet: a scale map of the site, including stages and an observation tower (print one copy per pair, preferably enlarging to A3 size). The grey circle represents the area that can be observed by the telescope.
- 4.3** Slides presenting the first main challenge
- 4.4** Video clip: (1'00") On stage, bewildered security staff are looking at some chalk, ropes and tape, while Mavis says: 'The lead singer may need to be winched to safety. I need you to mark the spot where he should stand so that he knows what to do.' The security staff discuss where the lead singer should stand in order to be winched from the stage.
- 4.5** A4 resource sheet: a scale plan of the triangular stage. There are two copies of the plan so that teams can have two attempts at the problem, but you may also need a few spare copies of the sheet.
- 4.6** Slides summarising the discussion between the two security staff
- 4.7** A4 resource sheet with a further problem (optional)
- 4.8** Video clip: (01'18") The crowd storms the stage during a rave performance. A helicopter arrives to winch Zak, the lead singer of The Prime Numbers to safety.

Other resources

Rulers, compasses, pencils, calculators and, as an option for the second main challenge, metre sticks, ropes and chalk.

Main activity

Tell the teams of four that you are going to present them with two challenges. They will then split into two pairs. Each pair will tackle both problems, in any order. The pair that finishes first can then help or check the work of the other pair.

Introduce the first main challenge. Show **Resource 4.1**, a video clip showing excited crowds gathering as dusk approaches (1'09"). Security staff erect a scaffolding surveillance tower and Mavis briefs the squad on the requirements for surveillance of Torbury Fields and the checks to be made.

Give out **Resource 4.2**, a scale map of the site (if possible, print this as an A3 sheet to make it easier for pupils to work in pairs), then show **Resource 4.3**, a slide presenting the challenge.

- From a tower it is possible to see clearly for 400 m if the view is uninterrupted. What area of Torbury Fields can be seen from the tower? Draw the area on your plan. How can you work out whether this is 85% of the site?
- Do you need to erect extra towers in order to be able to see 85%? If so, where?



Carry straight on with an introduction to the second challenge. Show **Resource 4.4**, a video clip showing Mavis explaining to security staff that they will need to mark a safe winching-off spot on the stage. The security staff look in bewilderment at a plan of the stage (1'00"). They discuss how they should work out where the lead singer should stand to be rescued in the event of an emergency.

Give out **Resource 4.5**, a scale plan of the triangular stage, and show the summary of the discussion on **Resource 4.6**, a slide.

- Where should Zak, the lead singer of The Prime Numbers, stand? Decide where you think the best spot would be and mark it on your scale plan.

Now set the teams to work.

Differentiation

Aim to give more support to any pairs who may struggle with the mathematical content or reasoning. In the first challenge you could prompt with questions like:

- How do you work out a percentage of a quantity?
- How do you work out the area of a circle?
- What happens when the same bit of the site can be seen from two different towers?
- What is 85% of the Torbury Fields area?

In the second challenge, pupils could, if you wish, use ropes and chalk to construct the place on a triangular stage marked on their playground. Prompts could include:

- Which spot of the stage would be the best for the lead singer to stand? Which position would be the fastest to get to if you were anywhere on the stage?
- The helicopter will hover over the stage. What shape is formed by the blades of the helicopter?
- If a spotlight is at a corner of the stage, which part of the stage must the helicopter avoid being over?
- For your safe spot, where do you think would be the best place to put the spotlights if you had only one spotlight? If you had two? If you had three? Justify your proposals.

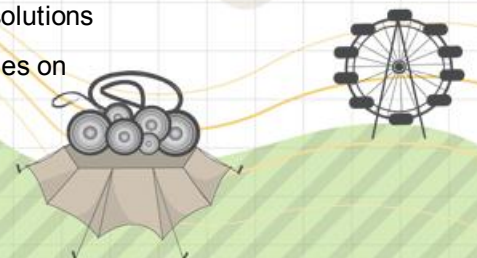
There is a further optional problem on **Resource 4.7** if you need it.

Review

Bring the whole class together to discuss the merits of their solutions and justify their decisions to the Health and Safety Coordinator for the site.

Round off the case study. Stress the process skills that pupils have applied during their lessons and the importance of these skills in mathematics, e.g.

- breaking down substantial tasks to make them more manageable
- exploring the effect of varying values
- representing problems in algebraic, geometrical or graphical form, and moving from one to another to gain a different perspective on a problem
- arguing convincingly to justify generalisations or solutions
- reviewing and refining own findings and approaches on the basis of discussions with others.



To conclude and celebrate, play **Resource 4.8**, a video clip showing the crowd storming the stage after a hugely popular performance (1'18"). A helicopter arrives to winch The Prime Numbers to safety.

Optional homework

If you are setting homework, ask pupils to do any remaining problem either from this lesson or from Lessons 1 to 3.

Optional assessment

You could list the objectives for the case study in pupil-friendly wording so that pupils can make their own assessment of their progress, perhaps using a traffic-light system. Alternatively, see the suggestions for assessment in the introduction to this case study.

Solutions for Lesson 4

Main challenge 1 (Resource 4.3)

The rectangular area of Torbury Fields is 1.2 km by 1.8 km, an area of 2.16 km^2 .

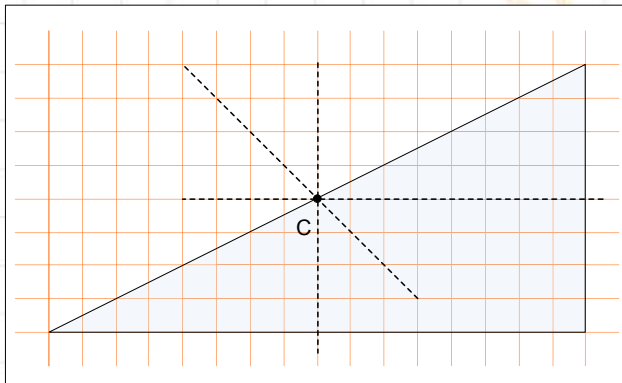
85% of this is 1.836 km^2 , so the area which can be observed by security staff must be **at least** this amount.

The observation tower marked on the map can observe a circular area with radius 400 m, i.e. an area of just over 0.5 km^2 or 23% of the site.

The rest of the solution will depend on pupils' decisions but find ways to encourage the most 'efficient' solution in terms of positioning.

Main challenge 2 (Resource 4.6)

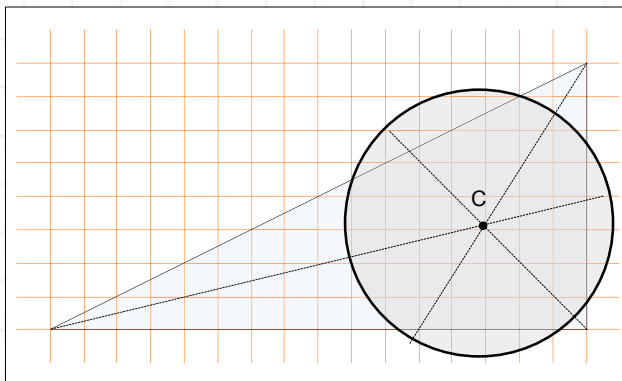
a There are various points where the lead singer could stand to be winched to safety. For example:



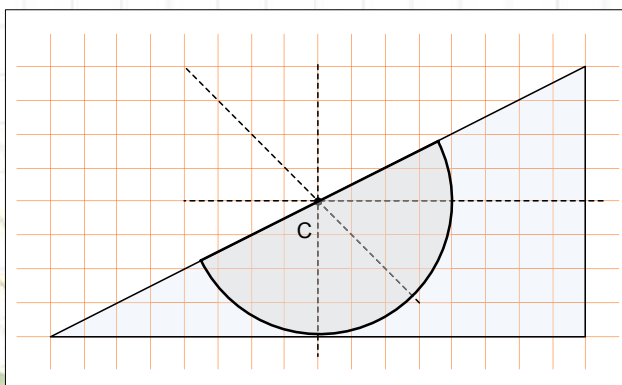
Drawing the perpendicular bisectors of the sides gives a centre C as shown here, a possible spot for the lead singer to stand.

All points of the triangle are less than the distance from the centre C to a vertex of the triangle, about 45 m.

b The spotlights must be placed outside a circle radius 20 m (4 cm), centre the selected winch point.



For example, if the lead singer stands at point C, the spotlights could be positioned anywhere outside the circle centre C radius 20 m (4 cm).



If the lead singer stands at Point C, the spotlights could be positioned anywhere outside the semicircle centre C radius 20 m (4 cm).

Pupils should come up with the answers in groups and then discuss the merits of their answers in a whole class session.



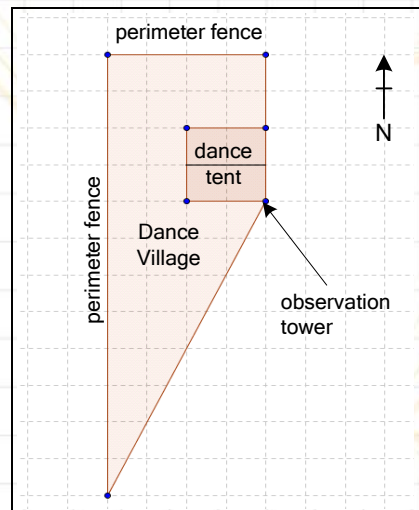
Further problems or homework (Resource 4.7)

The solutions will depend on the decisions that pupils make.

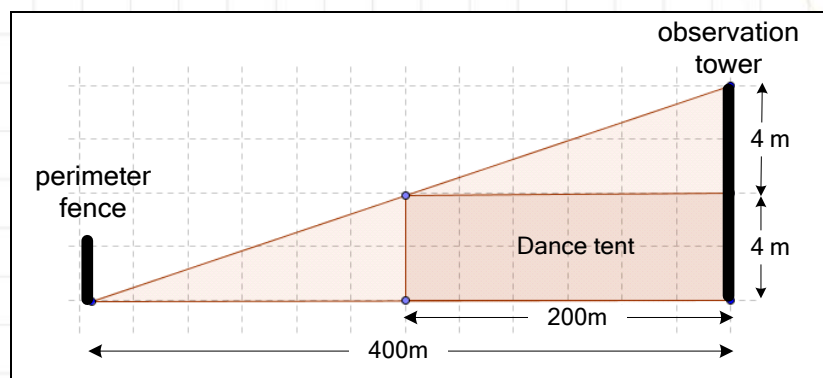
1 Pupils should realise that the dance tent:

- should not be situated against the exterior perimeter fence as the security staff would then not be able to see part of the fence;
- should be situated as close as possible to the observation tower in order to minimise the height that the tower needs to be to see over the dance tent.

For example, the dance tent could be positioned as in the diagram below, in which the side of one square represents 100 m. The central ridge of the roof runs east to west.



2 Pupils could sketch a diagram of the elevation to support their reasoning in calculating the height of the observation tower. For example, if the dance tent were positioned as in the diagram above, one solution, looking west, might be a tower of 8 metres in height:



Pupils could sketch similar diagrams to show that the same tower would be able to see over the central ridge of the roof looking both north and north-west.