Dear Escape Room Enthusiast,

Thank you for downloading these resources – the result of a one-off public engagement event we ran in Oxford in May 2019. We had a lot of fun putting the puzzles together and hope that you will have as much fun deciphering them.

The puzzles all link to research work being done at the Mathematical Institute in Oxford. You can find more details on the way in which they are related in the accompanying Explanations booklet.

Setting up the escape room activities requires someone to print and prepare the materials. Some items also need to be purchased. This document is aimed at the person who will be preparing the activities for others to take part in.

Please do let us know how you use these materials, and any feedback on how they can be improved for an online audience.

With best wishes,

The Oxford Mathematics Escape Room Team

Preparation Notes

We ran the Escape Room as a series of puzzles in different locations, with actors to play certain roles. We have tried to suggest adaptations where this is not possible in your set-up. You could, for example, set up the activity as a set of stations around a classroom or simply give each team the next clue when they complete the previous one for a less immersive but more practical event. This also means multiple teams can do it at the same time.

We found that teams of 2-3 work best to ensure that all members of the team remain engaged.

For each puzzle there are a series of hints that can be given out. If you are running the event to a timed limit, we suggest giving the hints out quite quickly (2-3 minutes) after starting a puzzle.

The activities do require a fair amount of printed material, and some equipment to be bought or made. Our recommendations based on what we used is given below, so you may want to use this shopping list guide.

Puzzle 5 (Marble Run)

Galt Toys Super Marble Run: This marble run only has 3 colours, so we used different colours of electrical tape to make it up to 6 colours.

Puzzle 8 (Locked Padlock)

Locked boxes: We used these for aesthetic effect, but there is no reason you couldn't use any box which can be secured with a padlock.

Padlocks: Any three-digit padlocks will do, so long as you can reset the code.

Puzzle 9 (Jigsaw)

Mirror cones: We had to make this from scratch, and you will find a document with instructions as part of this download. You will need mirror sheet and expanding foam.

Other items:

Acetate
White card

The Operations Room

Total expected duration: 20-40 minutes

Police Briefing

Expected Time: 3-7 minutes

You will need:
Printed Case Update from Chief Investigating Officer
Printed Fact sheet
Envelope with T-shapes

Note: The T-shapes are not needed until Puzzle 8 (The Locked Padlock). You could just provide it at that stage, if it suits your set-up better.

Storyline

The portrait of Henry Savile has been stolen from the office of the Savilian Professor of Geometry between 14.05 and 14.10. Police believe there may have been more than one culprit, and that the portrait has not left the building but is stashed somewhere to be retrieved later. They have found some muddy footprints, mysterious T-shapes, and their teams have been busy timing how long it would take to walk between different points in the building. The police also have CCTV available, but there is too much to go through without narrowing down the timeframe of when the thief entered the building.

How it works

These items set the scene and introduces the participants to the background of the crime. There is nothing to solve, but it provides participants with the information and clues they will need later on. These statements can be handed out as part of an introduction to the activity, simply stating that they provide some background.

Puzzle 1: Muddy Footprints

Expected Duration: 5-15 minutes

You will need:
Printed set of 9 footprints
Footprint overlay printed on acetate
Printed Intensity Gauge (on card is ideal)

Storyline

Smudged footprints were found all over the building, but no footprints were found heading out of the Savilian Professors office. Police believe the thief ran some errands and then realised they were leaving a trail and removed their shoes before leaving the office with the portrait. Not all the prints belong to the suspect, as many students play football and trek in mud on their shoes.

How it works

Each team has a set of nine footprints, the footprint overlay and an intensity gauge. They should use this to work out which footprint belongs to the thief based on a sample, and hence which locations they visited before stealing the portrait.

Solution

Footprint 8 belongs to the thief. Looking at these two regions in the nine footprints found by Forensics, there are three different possibilities for each square.
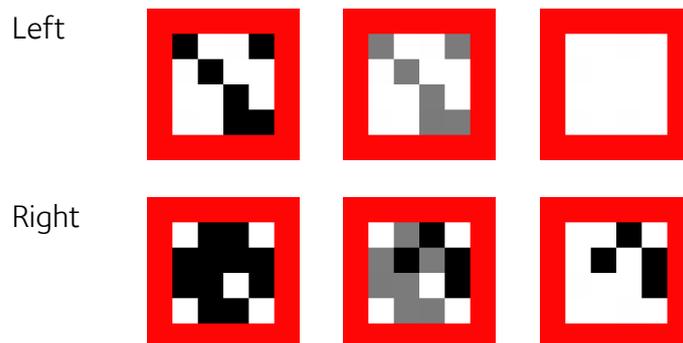
It's possible to see by eye now that for the suspect's footprint, we need the middle of the three boxes on the left, and the first box on the right. These correspond to footprint 8.

Puzzle 2: The Shortest Path

Expected Duration: 10-15 minutes

You will need:
Printed footprint locations map
Printed table of travelling times

Storyline

The thief entered the building and visited various locations before they stole the portrait, leaving muddy footprints as they went along, until they removed their shoes during the heist.

How it works

Having identified which is the thief's footprint, participants should now identify the locations the thief visited and the shortest path to visit all those locations. They also know the timeslot in which the portrait was stolen, so can work backwards to identify the time the thief entered the building, and hence which CCTV images to look at.

Solution

The thief took 430 seconds (that is, 7 minutes and 10 seconds) to move round the building, so we should look at CCTV for 13:57:50.

From the footprint information, we know that the thief entered the building at position 1, visited locations 3, 4 and 7, and then went to the Savilian Professor's office at 9 to steal the portrait.

The police have collected data on how long it takes to walk between locations. We have to find the shortest path that starts at 1, visits 3, 4 and 7 in some order, and finishes at 9. All journey times are given in seconds.

Here is a network representing the places we have to visit, along with the time taken for each leg in seconds.
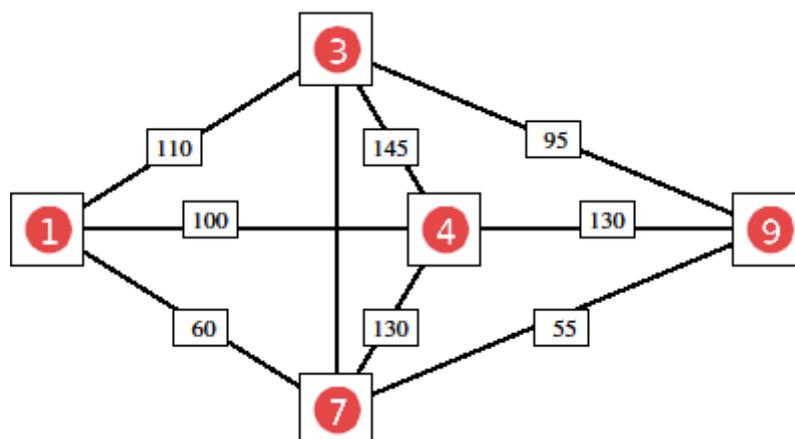
There are six possible routes, for the six possible orders of locations 3, 4 and 7. We can calculate the total time each would take:

Route	Time taken in seconds
$1 \rightarrow 3 \rightarrow 4 \rightarrow 7 \rightarrow 9$	440
$1 \rightarrow 3 \rightarrow 7 \rightarrow 4 \rightarrow 9$	505
$1 \rightarrow 4 \rightarrow 3 \rightarrow 7 \rightarrow 9$	435
$1 \rightarrow 4 \rightarrow 7 \rightarrow 3 \rightarrow 9$	460
$1 \rightarrow 7 \rightarrow 3 \rightarrow 4 \rightarrow 9$	470
$1 \rightarrow 7 \rightarrow 4 \rightarrow 3 \rightarrow 9$	430

The shortest path is the final one, which takes 430 seconds, that is, 7 minutes and 10 seconds.

Since the thief arrived at location 9, the Savilian Professor's office, at exactly 14:05:00, this means that they entered the building 7 minutes and 10 seconds earlier, at 13:57:50, and so this tells us which CCTV shots to look at.

Puzzle 3: CCTV

Expected duration: 1–3 minutes

You will need:
Printed CCTV images showing a person (x3 – they are one second apart) in an envelope with the correct time on it 13:57:50.
CCTV image showing nothing in frame in envelopes with red herring times 13:57:40, 13:56:35, 13:57:45, 13:57:20, 13:57:10, 13:57:50.

Storyline

CCTV at the entrance to the building might reveal the identity of the thief, if we can work out what timeslot to look at. Unfortunately, the footage has been corrupted and the entire image isn't available.

How it works

Having worked out the locations the thief visited and worked out the shortest possible time they could have visited all those locations, participants can work out the timeframe in which the thief must have entered the building. They can then look in the correct time slot of CCTV images to attempt to identify the thief.

The images show a photo that has information missing. By looking at the three consecutive images, they should be able to identify the name of the thief, as there is no one else in shot.

Solution

The CCTV shows the suspect holding their data science homework, with their name Martin Field on it.

The academic admin assistant

Puzzle 4: Lecture Timetabling

Expected duration: 12-20 minutes

You will need:
Handout with lecture timetabling constraints
ID cards

Note: The ID cards are not required until Puzzle 6 (The Newsletter), so if you prefer it could be handed out with the newsletter, if that suits your set-up better. Note that the colour on the newsletters and ID card need to be near identical, so print these on the same printer.

Storyline

The academic admin assistant may have some information. They are all flustered as they need to get an important timetable finished, but have been delayed because of the all the drama around the theft. They can talk to you only once the timetable is finished.

How it works

Each team gets a copy of the handout, and must correctly complete the timetable considering all the constraints. Once they have done this, the assistant can hand them an ID card that was found, that doesn't match anyone in the building and has no name.

Solution

	9am–10am		10am–11am		2pm–3pm	
	subject	room	subject	room	subject	room
Prof Anand	S1	L1	S2	L3	S3	L1
Prof Brown	S6	L2	S5	L1	S4	L3
Prof Chang	S7	L3	S9	L2	S8	L2

The Savilian Professor of Geometry

Puzzle 5: The Marble Run

Expected duration: 15–30 minutes

You will need:
Marble Runs with size different coloured bases – we used [Galt Super Marble Run](#) and put coloured electrical tape around to achieve 6 colours.
Marbles to test completed runs
Sheets explaining the constraints
Mirror Cone

Note: The cone is not required until Puzzle 9, so could be handed out with that puzzle if preferred.

Storyline

The Savilian Professor has some information, but is too distraught to talk as their precious marble run was knocked over during the heist. They are trying to put it back together but are struggling. They can remember some details, such as the colour of the start and exit bases.

[Note: if you do not have actors available, this could be presented as a task to gain a written statement]

Reconstruct the run so that it satisfies the following criteria:

entry above base coloured	exit at base coloured
red	orange
orange	purple
yellow	orange
green	orange
blue	yellow
purple	yellow

The run is three levels high above every base. The base pieces are in a circle in the order red, orange, yellow, green, blue, purple:

How it works

Each team gets a mixed-up marble run and a sheet of instructions telling them what the professor can remember about their marble run. They should use this information to correctly reconstruct the marble run to gain information from the professor.

Solution

To make it easier to see, here is the solution stretched into a line rather than a circle.

Newsletter

Expected total duration: 25–50 minutes

The newsletter is a combination of several puzzles in one document.

You will need:

Printed newsletters
Printed copies of the 'research paper'
Handbook of signalling systems
ID card

Note: Depending on how you set up the activities, the ID card can be gained from Academic Admin Assistant, or provided with the newsletter.

Storyline

The thieves have been communicating through coded messages in the department's newsletter. By decoding the messages, they can work out the name of the professor involved in the heist.

How it works

Each team gets a copy of the printed materials. By studying these, they should have all the information they need to decode the messages in the newsletter. There are two main puzzles: a faces board and coded message.

Puzzle 6: Coded message

The message reads "money in box".

In the article about Sir Henry Savile, there were several mistakenly capitalised letters. Taken in order, these spell the word TERNARY.

This indicates that the numbers under the article must be translated into ternary. The "research paper" *On the representation of numbers in different bases* helps with this. The result is

22 222 21 1 2122 11 21 2111 222 2112

Also, there are three words in the article that appear in a different font (san serif). Taken in order, these read well-known Oxford detective. This was a clue to Morse.

The numbers written in ternary represent letters written in Morse code. Here a 2 represents a dash – and 1 represents a dot · so the message becomes

— —   — — —   — · ·   — · — —   · ·   — ·   — · · ·   — — —   — · · —

The booklet of signalling systems helps to decode the letters, which translate as

M   O   N   E   Y   I   N   B   O   X

Puzzle 7: Photo board

The faces board reveals the name SMITH, which belongs on the ID card found by the Academic Admin Assistant.

The "Mondrian painting" was a clue to understanding the faces board. Viewed from a shallow angle, it shows the words

WHICH NEW STUDENTS SHARE TRAITS WITH THE PHOTO ID

There were five clues, one for each blank letter space on the ID card, hidden in different places in the Newsletter. Each clue is to a trait, and each trait gives a letter. The five traits are glasses, eye colour, tie, clothes colour, and hair colour. We need to identify which of the new students share each trait with the photo ID (that is, no glasses, brown eyes, wearing a tie, blue clothes, dark brown hair). For each trait, the position of the students in the grid spells out a letter. The letters are S, M, I, T, H, giving the name Smith.

The articles that give clues to the five traits are the articles mentioned on the front cover of the Newsletter.

In the box "In This Issue…", the first (coloured) letters of the 2018 highlights and 2019 resolutions of Mathematical Institute members spell out GLASSES.

In the box "Oxford Mathematical Alphabet", there are three posters. Each one is an I (eye), but they are in different colours. This is a clue for EYE COLOUR.

In the box "Art exhibition", the Mondrian painting is called *Composition in red, blue and green*. Looking at the colour squares in the painting, the red squares form the letter T, the

blue squares form the letter I, and the green squares form the letter E. Taken in order, these spell TIE.

On the back page, the geometric shapes at the top and bottom of the page correspond to two words that have been sliced in half (and turned upside down). The words can be identified by folding the newsletter to match the edges. This gives CLOTHES COLOUR.

In the box "Research highlights", the labelled points on the figure spell out HAIR (red points taken clockwise) COLOUR (black points taken from left to right).

Professor Smith's Office

Total expected duration: 15-30 minutes

Puzzle 8: The locked padlock

Expected duration: 10-20 minutes

You will need:
Printed sheets with incomplete information
T-shapes gained during the police briefing
Cellular automata clues, written and photocopied or on a board

Note: The T-shapes could also be given out with this puzzle if that suits your set-up better.

Storyline

Having identified Professor Smith as the accomplice, the teams go to his office. There they find a locked box (as mentioned in the newsletter), a sheet with some smudged numbers. On the board is an explanation of the process.

How it works

Teams should use the clues provided on the board to complete the grid on the paper and reveal a three-digit number, which will open the lock on the box.

Solution

To unlock the padlock, we need the three-digit code 206.

Each row represents a state of the system. To move from one row to the next, we must follow rules given by the T-shapes. The colour of each box at the next step depends on its colour and also the colours of its two neighbours either side. Only the highlighted squares have to be filled in, because the boxes at the edge of the grid are known to be white.

Here is the full grid, with some of the T-shapes highlighted.

To find the numbers in the column on the right, we think of each row as giving the binary representation of a number. Here black represents 1 and white represents 0. There was a
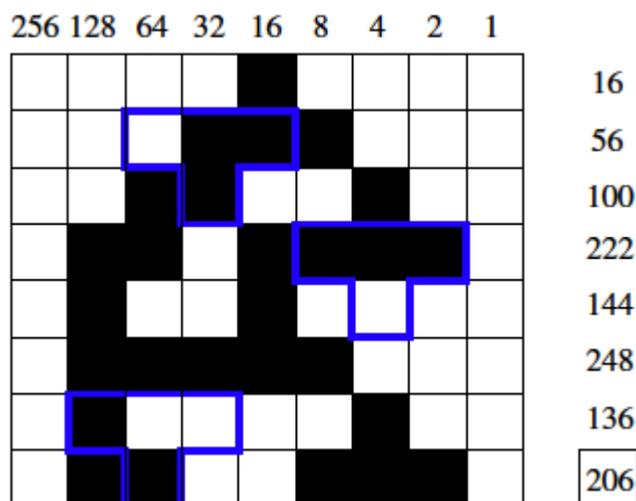
clue in the numbering of the T-shapes, because each is labelled with the number corresponding to the top row of the T with the same binary representation.

Puzzle 9: The Jigsaw

Expected duration: 5-10 minutes

You will need:
Jigsaw pieces (placed inside box)
Cone (gained from Savilian Professor)
Printed Plant Room sign
Printed picture of Henry Savile (or any other 'stolen' item of your choosing!)

Note: The cone could be placed inside the box with the puzzle pieces if you prefer and that suits your set-up better.

Storyline

Once Martin Field had stolen the painting, he retrieved his money from Professor Smith's office and left a clue as to where he's stashed it, for later retrieval.

How it works

Having opened the box, the team finds a set of mixed up puzzle pieces and a note stating "left the portrait here". They should assemble to puzzle pieces, place the cone in the middle and then look from above to reveal the symbol for the Plant Room. This is where the portrait is stashed.

Solution
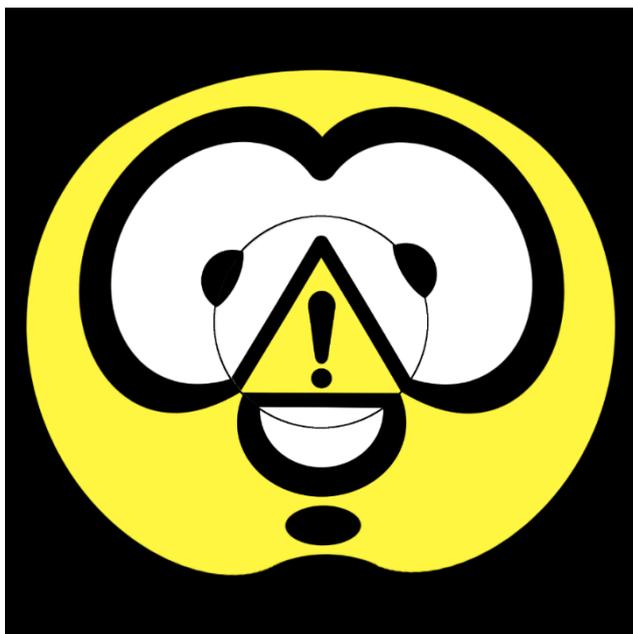
Choose somewhere to hide the portrait and place the plant room sign nearby to lead participants to look for the portrait there.