



# **MaPP Challenge '20 – Mystery of the Missing Archeologist**

*Mathematical Puzzle Programs*



MaPP Challenge '20 – Mystery of the Missing Archeologist

# How to Play

## Rules

### Leagues

Each team is registered in either the **Competitive or Recreational League**. If both Leagues are playing simultaneously today at your campus, then all scoring and awards are handled separately in both Leagues.

### Puzzle Packets and ClueKeeper

Each team has received multiple **Puzzle Packets**. However, there is not enough information in this packet to begin solving any puzzles.

Once the game begins, clues will become available in the **ClueKeeper** app that will allow players to begin solving puzzles in the packet. Once a puzzle is solved, its solution can be submitted via the app. As time progresses, hints for unsolved puzzles will unlock, helping teams who are stuck. The game ends when your time in ClueKeeper has expired.

The Bonus Puzzle solution is submitted directly to Game Control (not ClueKeeper) and is awarded partial credit, see below for details.

### Main Puzzles

Once the game begins, you'll be presented with four mini-puzzles, each of which unlocks a **Main Puzzle**. If your campus is using Cluekeeper's GPS functionality, you will have take your device to a certain location on campus in order to unlock each puzzle.

Each Main Puzzle can be solved directly using mathematical modeling and problem-solving abilities. Each puzzle solves to a short word or phrase. Correct solutions are worth **1500 Victory Points each** for a total of **6000 Victory Points**.

### Cryptic Puzzles

You will be given the opportunity to solve an additional **Cryptic Puzzle** after every Main Puzzle you solve. The way to solve these puzzles is left, well, cryptic. However, your team should still be able to use your critical thinking to extract a hidden word or phrase. Correct solutions are worth **500 Victory Points each**, for a maximum total of **2000 Victory Points**.

### Bonus Puzzle

After solving all four Main Puzzles, the Bonus Puzzle will become unlocked in ClueKeeper. Your team will be asked to optimize a certain task, and present your solution to Game Control in person, which will be graded and awarded **up to 500 Victory Points**.

You may submit up to three solutions throughout the game (including any disqualified submissions), and your best solution of the three will be counted toward your score.

## Metapuzzle

Once your team has solved two Cryptic Puzzles, the final **Metapuzzle** becomes available, worth **1000 Victory Points**.

## Another Puzzle?

We cannot confirm nor deny the ability to earn an additional **500 Victory Points**, somehow.

## Hints

Recreational teams may ask for hints at Game Control at any time during the game, and may receive direct assistance from their teachers/chaperones as desired. Competitive teams may ask Game Control for rules clarifications, but otherwise will only receive help via hints made available in ClueKeeper.

## Winning the Game

The team that earns the **most Victory Points out of 10000** by the end of the game is the **winner**. If any teams are tied, then the tie will be broken based on how quickly those teams solved their puzzles (the time each team submitted its last correct non-Bonus puzzle solution).

## Additional Rules/Advice

- Players should not do anything which would interfere with other teams solving puzzles. Be a good sport!
- Submissions for each puzzle, besides the Bonus Puzzle, are unlimited. Every submission for the Bonus Puzzle will be carefully graded by Game Control, so only three submissions are allowed.
- Before visiting Game Control to ask for a hint or clarification, make sure you've read all the material accompanying the puzzle! Chances are, your question is covered there.
- Teachers and chaperones are not allowed to help Competitive teams solve puzzles.
- Teams may use any supplies they've brought and even look things up online to solve puzzles, but Competitive Teams may not receive any direct assistance from outside their team (e.g. you can't Phone a Friend).
- Players must remain within any physical boundaries set by both Game Control and their teacher/chaperone at all times, and must always travel with a teammate when leaving their headquarters.
- Teachers/chaperones are responsible for their students at all times.
- Since this game will be played at different campuses on different days, please do not spoil any of today's puzzles or solutions online until the game book is released publicly by MaPP!
- Contact Game Control immediately in the case of emergency or any issues with these rules.



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## Game Resources

### Reference Sheet

Letter	Decimal	Binary	Morse	Braille	ROT13	Letter	Decimal	Binary	Morse	Braille	ROT13
A	1	00001	.-	⠠	N	N	14	01110	-.	⠠	A
B	2	00010	-...	⠡	O	O	15	01111	---	⠡	B
C	3	00011	.-.	⠢	P	P	16	10000	.--.	⠢	C
D	4	00100	-..	⠣	Q	Q	17	10001	--.	⠣	D
E	5	00101	.	⠤	R	R	18	10010	.-.	⠤	E
F	6	00110	..-	⠥	S	S	19	10011	...	⠥	F
G	7	00111	--.	⠦	T	T	20	10100	-	⠦	G
H	8	01000	....	⠧	U	U	21	10101	..-	⠧	H
I	9	01001	..	⠩	V	V	22	10110	...-	⠩	I
J	10	01010	.---	⠪	W	W	23	10111	.--	⠪	J
K	11	01011	-.-	⠫	X	X	24	11000	-..-	⠫	K
L	12	01100	.-..	⠬	Y	Y	25	11001	-.-.	⠬	L
M	13	01101	--	⠭	Z	Z	26	11010	--..	⠭	M

### Some famous numbers and formulas

$\sqrt{2} \approx 1.41421\ 35623\ 73095\ 04880\ 16887\ 24209$  Pythagorean Theorem  
 69807 85696 71875 37694 80731 76679 73799  
 07324 78462 10703 88503 87534 32764 15727

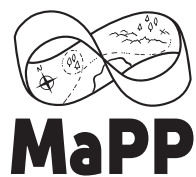
$$a^2 + b^2 = c^2$$

$e \approx 2.71828\ 18284\ 59045\ 23536\ 02874\ 71352$  Quadratic Formula  
 66249 77572 47093 69995 95749 66967 62772  
 40766 30353 54759 45713 82178 52516 64274

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$\pi \approx 3.14159\ 26535\ 89793\ 23846\ 26433\ 83279$  Euler's Formula  
 50288 41971 69399 37510 58209 74944 59230  
 78164 06286 20899 86280 34825 34211 70679

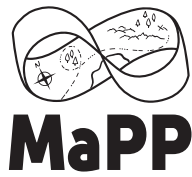
$$e^{ix} = \cos(x) + i\sin(x)$$



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## **Opening Puzzle**

The Numbers Text



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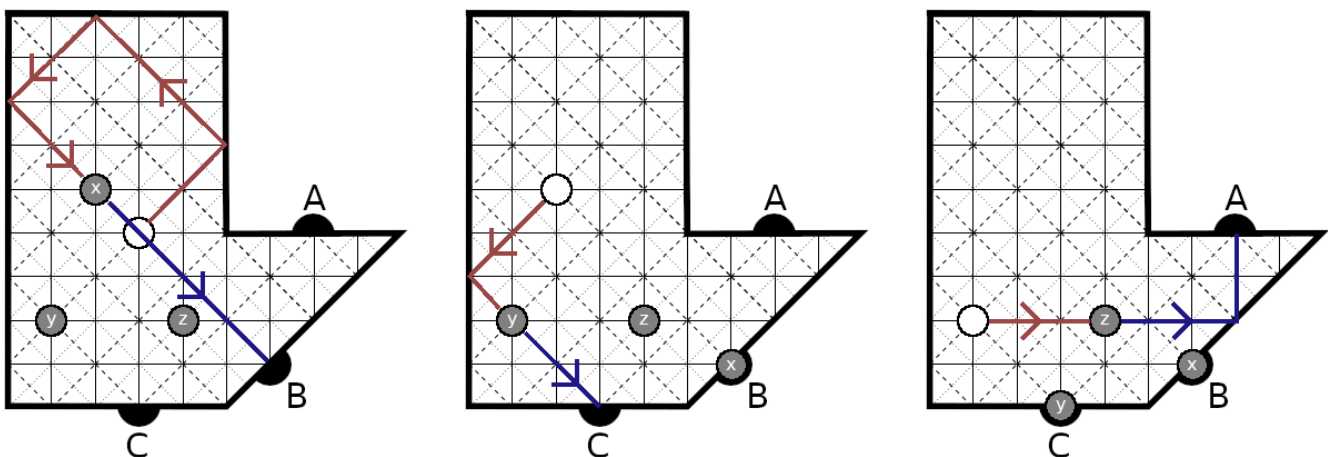
# Main Puzzle 1

## The Fox and the Rabbits

Dr. Mindy Jonas' first major discovery was the remarkable boulder game of the Fregian people. The Fregian kings build massive arenas with a fantastic variety of shapes and sizes. After surviving a harrowing encounter with a boulder in a long-lost temple, Dr. Jonas found an ancient tablet. On that tablet, the rules to the game were literally written in stone:

- The game was played with two kinds of boulders: a white one called the fox and several darker ones, called the rabbits.
- The goal of the game was for the the fox to hit the rabbits into the holes at the edge of the arena. Exactly one rabbit would be hit into each hole.
- The fox could only be launched along the marked vertical, horizontal, and diagonal trajectories. When it collided with a rabbit, the fox would take the place of the rabbit and the rabbit would continue in the direction it was hit.
- The rabbits were not allowed to strike each other, and no boulder was allowed to hit a sharp corner in the arena.
- Once moving, a boulder would continue to move around the arena indefinitely, bouncing off walls until it struck another boulder or sunk into a hole.

Dr. Jonas recorded five arenas for this game in her journal. In each one there is a unique way to win the game. Dr. Jonas' assistant, Brandon Fraiser, thinks that the solution to these puzzles will help you find the hidden message in Dr. Jonas' journal page. Thankfully, Fraiser has already solved one of the arenas as an example:



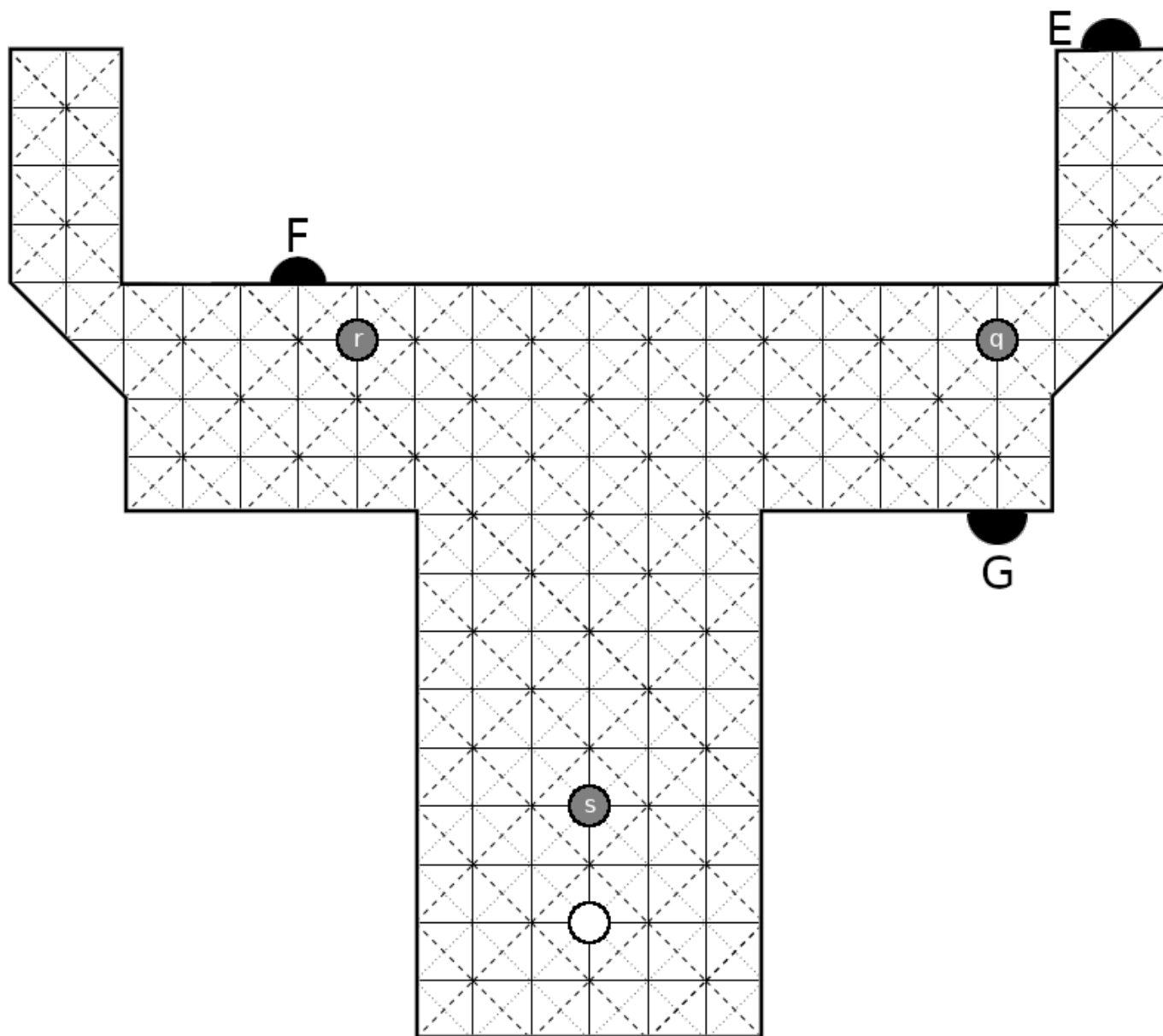
The solution to this arena is xB-yC-zA. Solve each of the four other provided arenas, and enter each solution into ClueKeeper using this format.



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## Arena 1

Balls: s, q, r – Holes: E, F, G

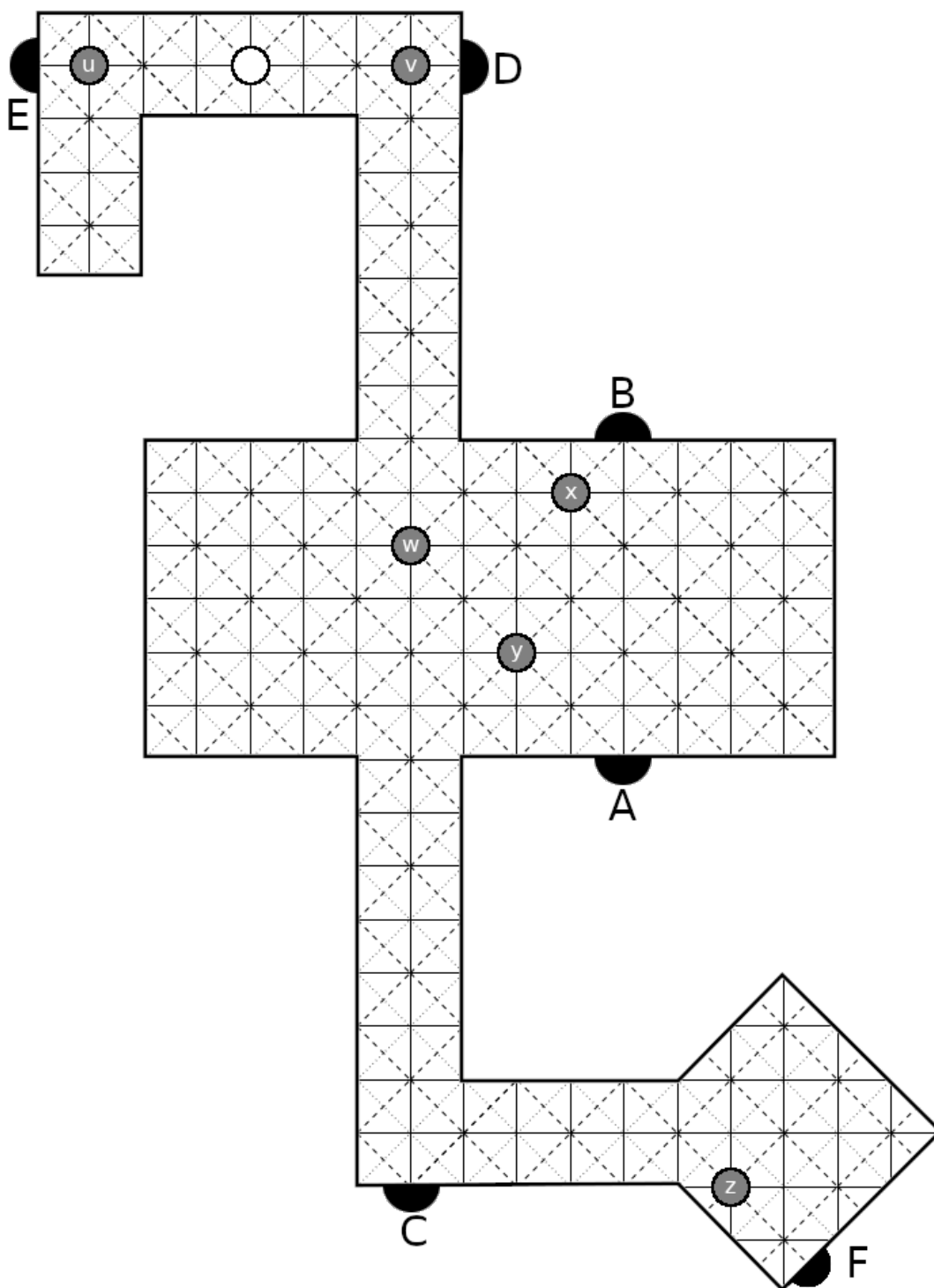




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## Arena 2

Balls: u, v, w, x, y, z – Holes: A, B, C, D, E, F



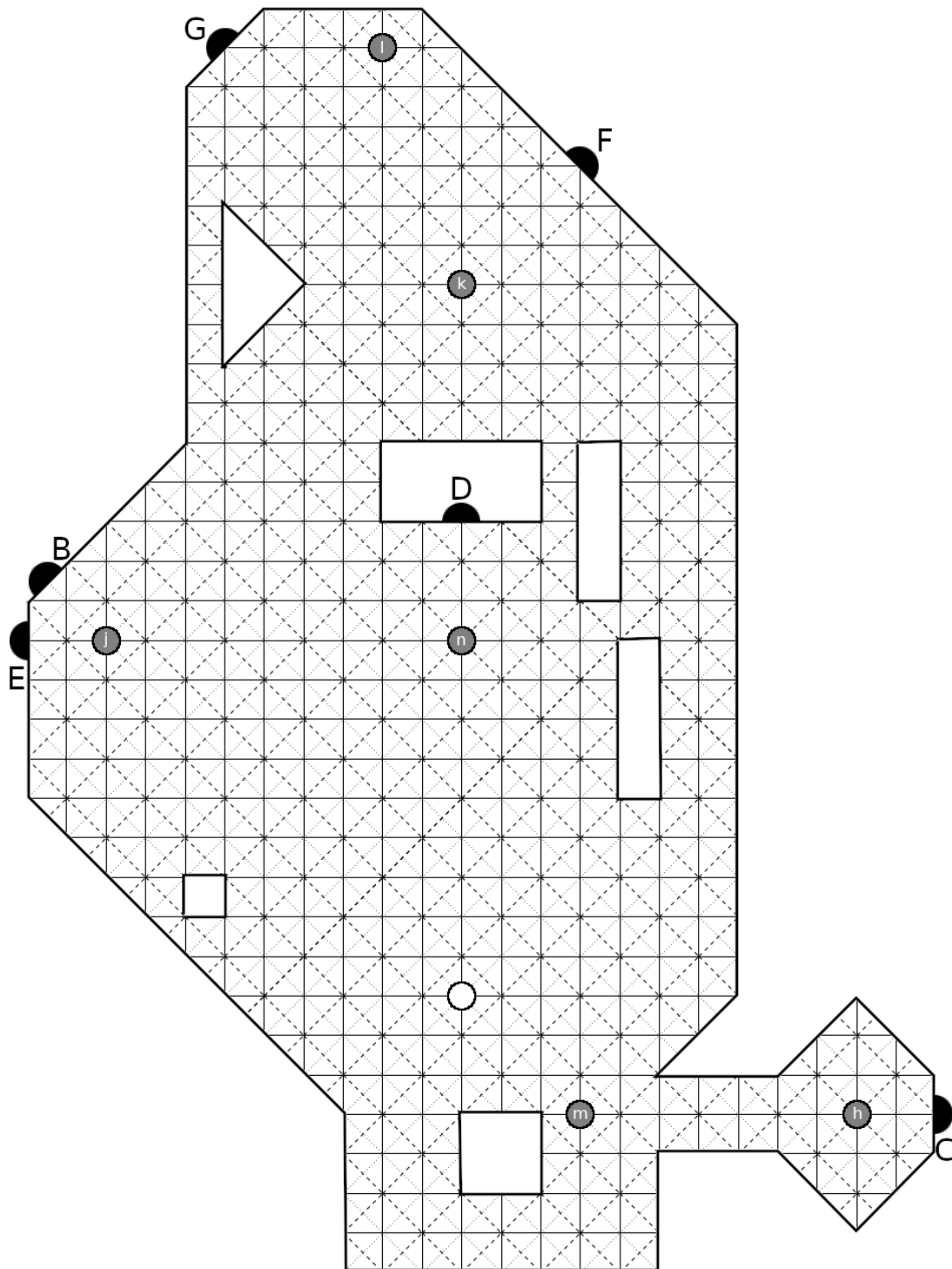


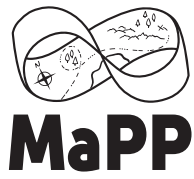


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## Arena 3

Balls: j, k, l, m, n, h – Holes: B, C, E, F, G

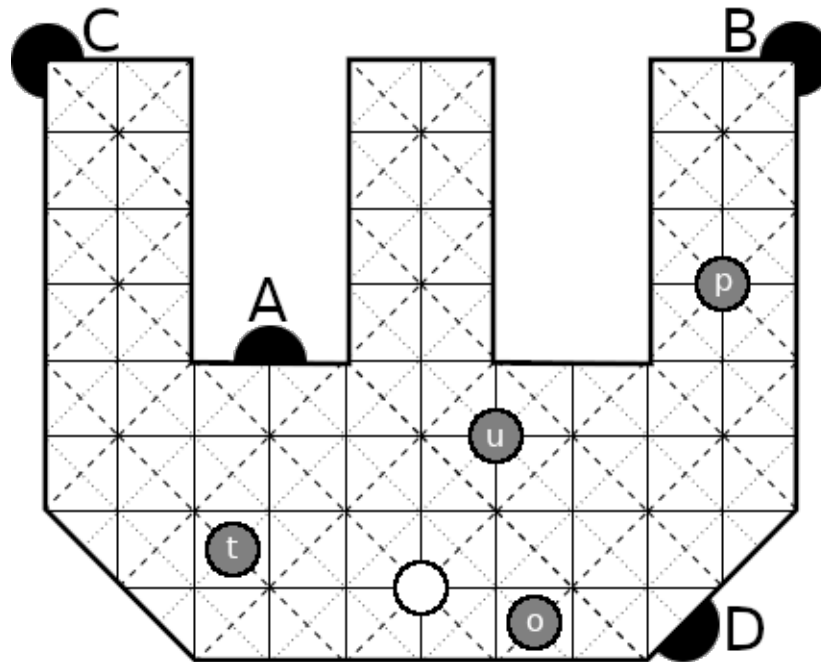


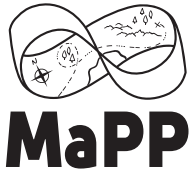


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## Arena 4

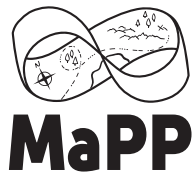
Balls: o, p, t, u – Holes: A, B, C, D





## Journal Page 1

Journal	entry	June	28,	1995		
	Successful	dig	today.	We	found	a
lot	of	pot	shards,	some	with	remarkably
intact	artwork.	Like	in	the	tomb,	there
are	scenes	of	men	with	circles	around
their	heads,	looking	to	the	sky.	We
believe	these	represent	past	kings,	deities	, or
maybe	both.	I	recall	my	advisor's	words,
people	are	not	pots."	I	should	be
careful	before	drawing	any	firm	conclusions.	On
the	other	end	of	the	site	from
the	tomb	we	found	a	burial	site.
It	was	lined	with	red	ochre,	the
bodies	were	facing	east	with	their	arms
folded.	Already	this	site	has	yielded	so
much.	If	only	the	university	understood.	They
want	to	save	money	so	badly,	but
what	is	it	for	if	not	this?



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## Main Puzzle 2

### The Ancient Bazaar

The Skolem people of Mesopotamia had many myths and legends. Of great interest to Dr. Jonas was the story of queen Noether, famed for her ability to barter with traders and merchants. You may have met a good haggler or two in your day, but they didn't have to deal with the strange ways of the Skolem Bazaar. The Skolem people had no money, instead goods were exchanged for other goods. Moreover, at the start of each day the shopkeepers would declare their exchange rates. They were notoriously stubborn and would not change these rates no matter what happened.

Dr. Jonas believed that Noether was real, and wanted to learn as much about her as possible. Unfortunately, over time every story about Noether split into multiple versions. In one, Noether entered the marketplace with one bag of spice.

- The first shopkeeper declared that 1 bag of spice is equivalent to 4 shell bracelets and 1 clay cup.  
( $S \leftrightarrow 4B + C$ )
- The second shopkeeper declared that 1 shell bracelet is equivalent to 3 bags of spice and 3 clay cups.  
( $B \leftrightarrow 3S + 3C$ )
- The third shopkeeper declared that 1 clay cup is equivalent to 1 bag of spice and 1 shell bracelet.  
( $C \leftrightarrow S + B$ )

There are two versions of the story:

1. Noether entered the bazaar with 1 bag of spice and left with 7 clay cups.
2. Noether entered the bazaar with 1 bag of spice and left with 7 shell bracelets.

Dr. Jonas reasoned that the first version was possible and that the second was impossible. Version one could happen the following way:

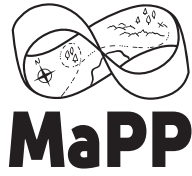
1. Go to shopkeeper 1:  $S \rightarrow 4B + C$
2. Go to shopkeeper 2 and use 1 shell bracelet:  $4B + C = B + 3B + C = 3S + 3C + 3B + C = 3S + 3B + 4C$
3. Go to shopkeeper 3 to get a clay cup:  $3S + 3B + 4C = 3C + 4C = 7C$

So why is the second version impossible? Consider the total amount of bags of spice and clay cups:  $S + C$ .

- The first shopkeeper does not change this amount.
- The second shopkeeper increases/decreases this amount by 6.
- The third shopkeeper does not change this amount.

Since Noether starts with  $S + C = 1$ , it can only become 1, 7, 13, and so on. So it is impossible for her to end up with exactly 7 bracelets. In cluekeeper, this solution would be put in as PI. If there were five variants which were possible, impossible, impossible, possible, and impossible, the solution would be PIIPPI.

There are many more stories about Noether. If you can figure out which ones are possible and which are impossible, you might be able to decipher the message hidden in Dr. Jonas' journal.



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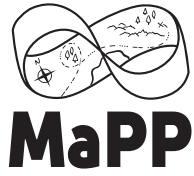
## Story 1

Pomegranates, Fish, and Bread

- The first shopkeeper declared that 1 pomegranate is equivalent to 1 fish. ( $P \leftrightarrow F$ )
- The second shopkeeper declared that 1 fish is equivalent to 1 pomegranate, 1 fish, and 1 loaf of bread. ( $F \leftrightarrow P + F + B$ )
- The third shopkeeper declared that 1 loaf of bread is equivalent to 1 pomegranate and 1 fish. ( $B \leftrightarrow P + F$ )

Label the following versions of the story as possible or impossible.

1. Noether entered the bazaar with 1 pomegranate and left with 2 pomegranates.
2. Noether entered the bazaar with 1 pomegranate and left with 3 pomegranates.
3. Noether entered the bazaar with 1 pomegranate and left with 3 pomegranates and 1 fish.
4. Noether entered the bazaar with 1 pomegranate and left with 1 loaf of bread.
5. Noether entered the bazaar with 2 pomegranates and left with 2 loaves of bread.



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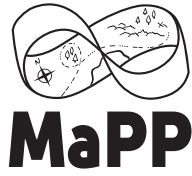
## Story 2

Tapestries, Saddles, and Vases

- The first shopkeeper declared that 1 tapestry is equivalent to 1 saddle and 1 vase. ( $T \leftrightarrow S + V$ )
- The second shopkeeper declared that 1 saddle is equivalent to 1 tapestry and 1 saddle. ( $S \leftrightarrow T + S$ )
- The third shopkeeper declared that 1 vase is equivalent to 1 tapestry and 1 vase. ( $V \leftrightarrow T + V$ )

Label the following versions of the story as possible or impossible.

1. Noether entered the bazaar with 1 tapestry and left with 3 tapestries.
2. Noether entered the bazaar with 1 tapestry and left with 50 tapestries.
3. Noether entered the bazaar with 1 tapestry and left with 1 tapestry and 1 saddle.
4. Noether entered the bazaar with 1 tapestry and left with 1 vase.
5. Noether entered the bazaar with 2 tapestries and 1 vase and left with 1 tapestry.



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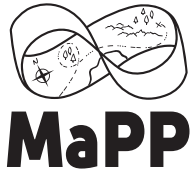
## Story 3

Spice, Vases, and Magic Crystals

- The first shopkeeper declared that 1 bag of spice is equivalent to 1 vase. ( $S \leftrightarrow V$ )
- The second shopkeeper declared that 1 vase is equivalent to 1 bag of spice and 1 magic crystal. ( $V \leftrightarrow S + C$ )
- The third shopkeeper declared that 1 magic crystal is worth 2 magic crystals. ( $C \leftrightarrow 2C$ )

Label the following versions of the story as possible or impossible.

1. Noether entered the bazaar with 1 bag of spice and left with 2 bags of spice.
2. Noether entered the bazaar with 2 bags of spice and left with 1 bag of spice and 2 vases.
3. Noether entered the bazaar with 3 bags of spice and left with 3 magic crystals.
4. Noether entered the bazaar with 1 bag of spice and left with 1 vase and 2 magic crystals.
5. Noether entered the bazaar with 4 bags of spice and left with 2 bags of spice, 2 vases, and 5 magic crystals.

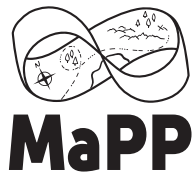


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## Journal Page 2

To be filled in by Steven.





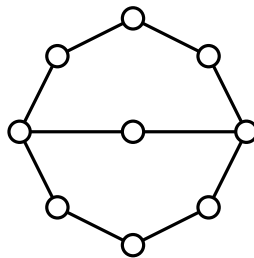
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# Main Puzzle 3

## Searching the Tombs

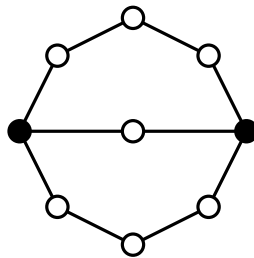
The necropolis of Ramsey is a complex of underground mausoleums, buried by earth and time. It is also where Dr. Jonas almost got fired. After finding her first mummy, she seemed to be cursed. Whenever she entered a new crypt, the mummy inside of it would be as far away from her team as possible. It's not that they had a hard time finding the mummies, in fact the walls had directions on them leading straight to the sarcophagus. Still, she had of run of impossibly bad luck.

Once the university realized how much resources Dr. Jonas was spending on her digs, they demanded she stop “wasting” their money. She needed to minimize the number of rooms her team was exploring. Using ground penetrating radar, Dr. Jonas was able to scout out possible sarcophagus locations and the passages between them. For instance, one site looked like



where the circles represent rooms and the lines represent the passages connecting them.

Dr. Jonas could send 9 people out to the site and find the mummy immediately, but that's not very efficient. With just 2 people, one of them will visit 1 chamber, and the other will visit 3, for a total of 4 chambers.



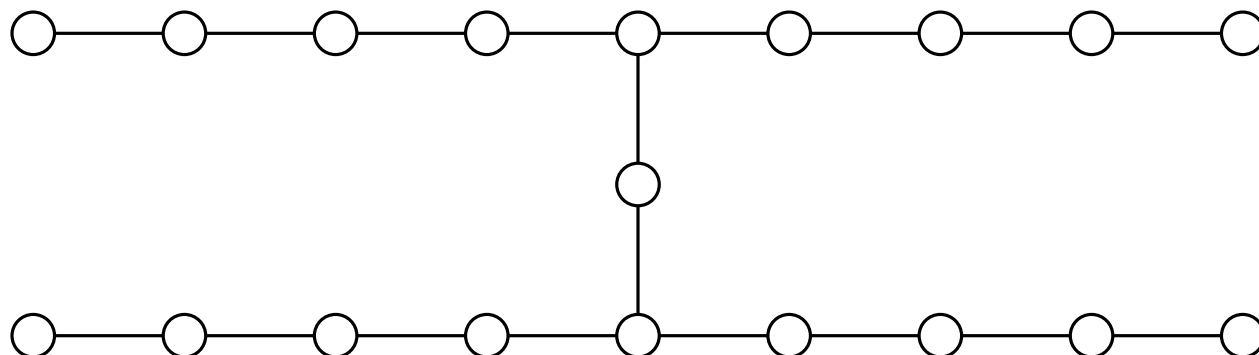
This is the best that Dr. Jonas can do (In cluekeeper, the answer will be 2 people, 3 rooms).

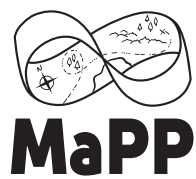
There are four more site diagrams in Dr. Jonas' notes. If you can figure out the minimum cost of exploring these crypts, B. Fraiser will be able to tell you how to decipher the next journal page.



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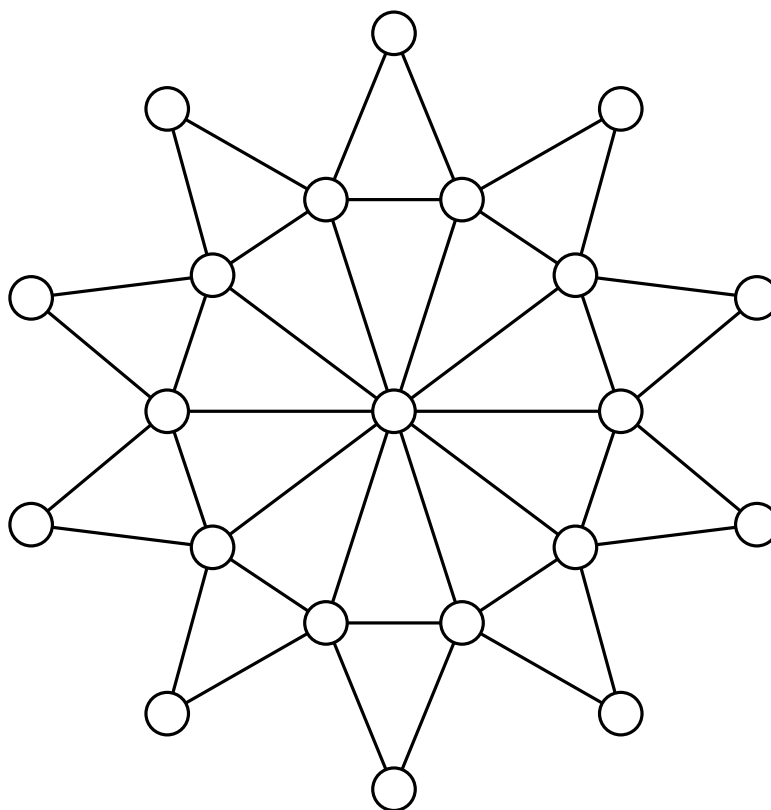
## Site 1

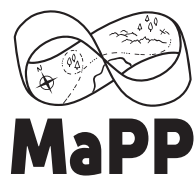




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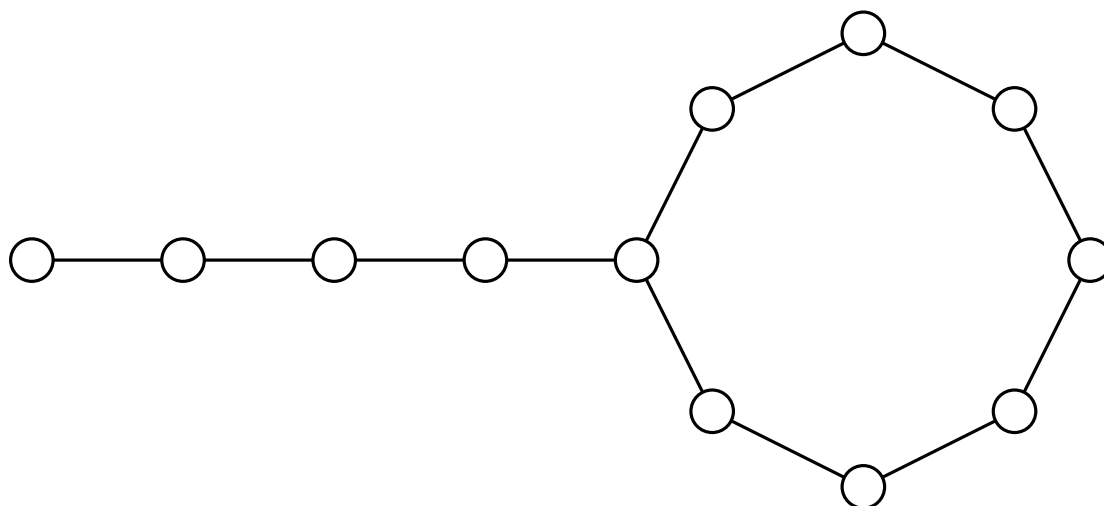
## Site 2

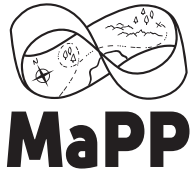




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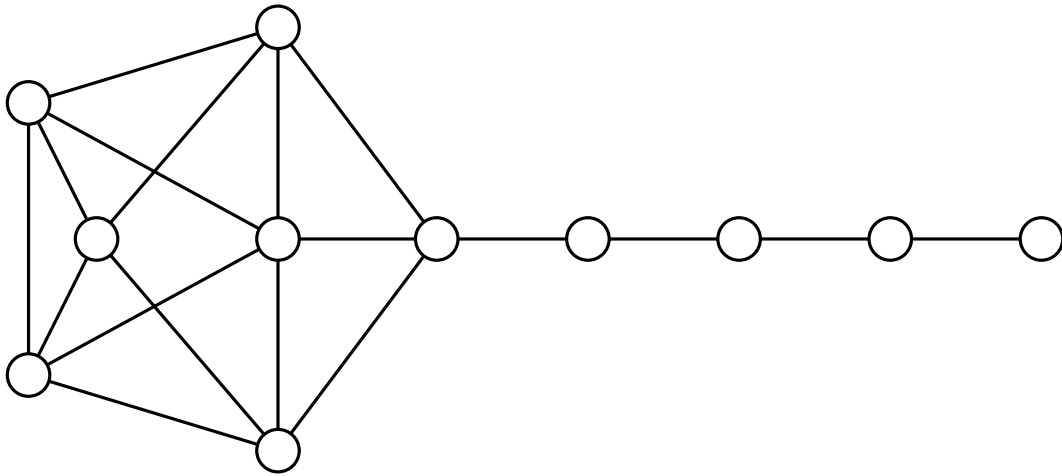
## Site 3





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## Site 4

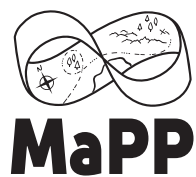




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# Journal Page 3

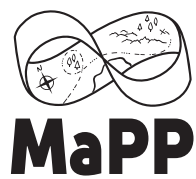
To be filled in by Steven as well I think. Coordinates encircle a picture I think.



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## **Main Puzzle 4**

Ancient Gerrymandering

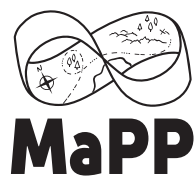


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## **Cryptic Puzzle 1**

Word Graph Thing

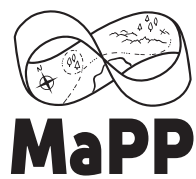




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## **Cryptic Puzzle 2**

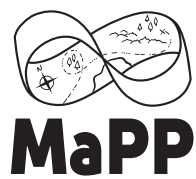
Switchboard



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## Cryptic Puzzle 3

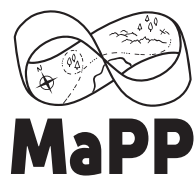
???



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## Cryptic Puzzle 4

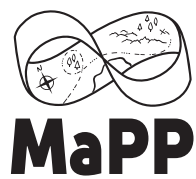
???



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## **Bonus Puzzle**

Azul Puzzle



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## **Meta Puzzle**

Alien Conversation