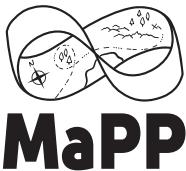


# MaPP

## MaPP Challenge '19 – To Aleph-Zero And Beyond

*Mathematical Puzzle Programs*

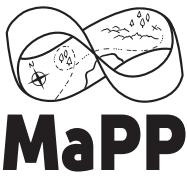


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MaPP Challenge '19 – To Aleph-Zero And Beyond

# Game Resources

## Scoresheet

Game Control and your team each have a copy of this scoresheet. When submitting solutions, bring your team's copy to Game Control to be updated.

School Name	Team Name/ID	League

### Main Puzzles

1500VP for each Main Puzzle solved; Time Solved used to break ties in VP

1	Good News Everyone	Time Solved	VP Earned
2	Extraterrestrial	Time Solved	VP Earned
3	Wibbly-Wobbly Timey-Wimey	Time Solved	VP Earned
4	Jumping Through Hyperspace	Time Solved	VP Earned

### Cryptic Puzzles

500VP for each Cryptic Puzzle solved; Time Solved used to break ties in VP

1	Hailing Frequencies Open	Time Solved	VP Earned
2	Out of Gas	Time Solved	VP Earned
3	AI Odyssey	Time Solved	VP Earned
4	Word Problem	Time Solved	VP Earned

### Bonus Puzzle

Up to 500VP for best submission

The Cosmic Wheel	First Submission	Second Submission	Third Submission	VP Earned
------------------	------------------	-------------------	------------------	-----------

### Metapuzzle

1000VP if solved, Time Solved used to break ties in VP

To The Rescue!	Time Solved	VP Earned
----------------	-------------	-----------

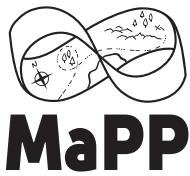
Up to 500VP if earned, Time Acquired used to break ties in VP

Additional VP	Time Acquired	VP Earned
---------------	---------------	-----------

Latest Time      10,000VP Maximum

### Final Score

--	--



MaPP Challenge '19 – To Aleph-Zero And Beyond

# 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

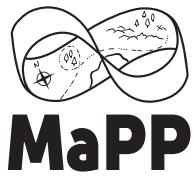
$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$\pi \approx 3.14159\ 26535\ 89793\ 23846\ 26433\ 83279$  Euler's Formula

50288 41971 69399 37510 58209 74944 59230

78164 06286 20899 86280 34825 34211 70679

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

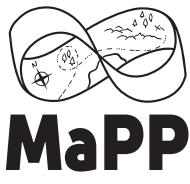


MaPP Challenge '19 – To Aleph-Zero And Beyond

## Game Resources

Start Code

# INFINITY

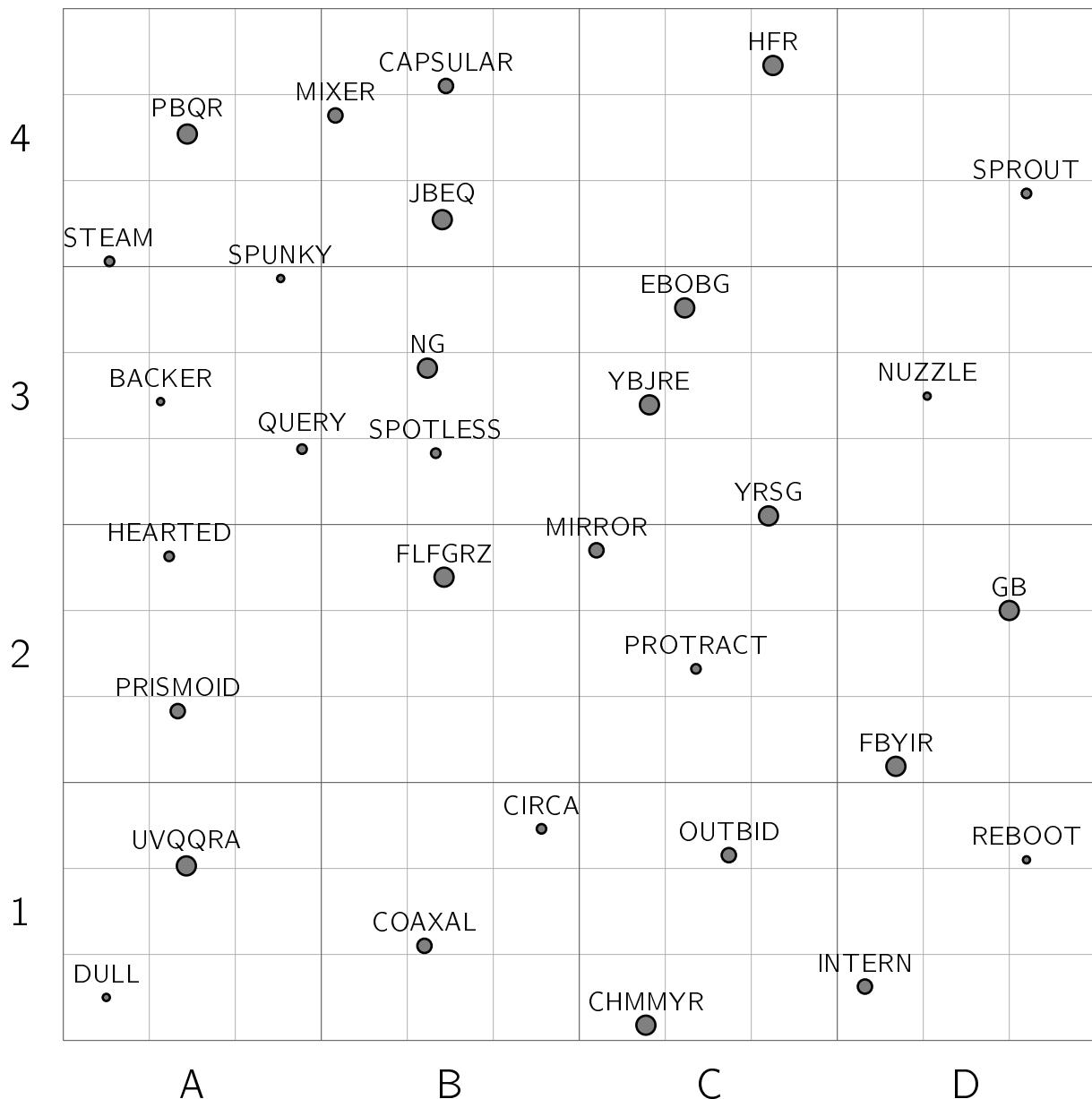


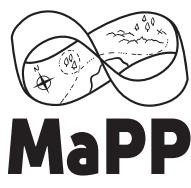
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# Game Resources

## Galaxy Chart

The smallest gridlines below measure a distance of 1000 parsecs. Each dot represents a solar system, known simply as Systems in this part of the galaxy.

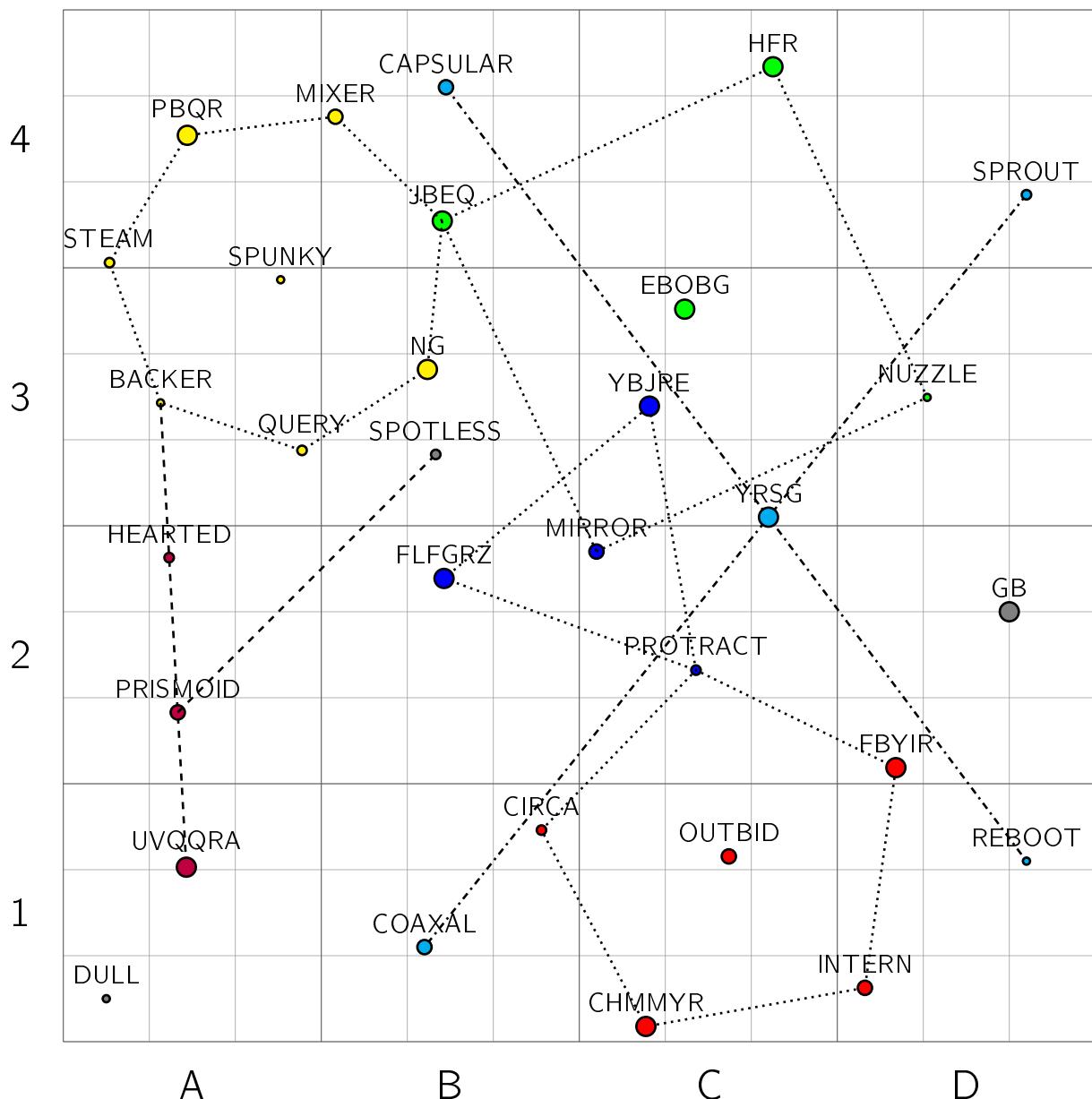


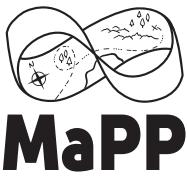


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# Game Resources

Galaxy Chart - Complete





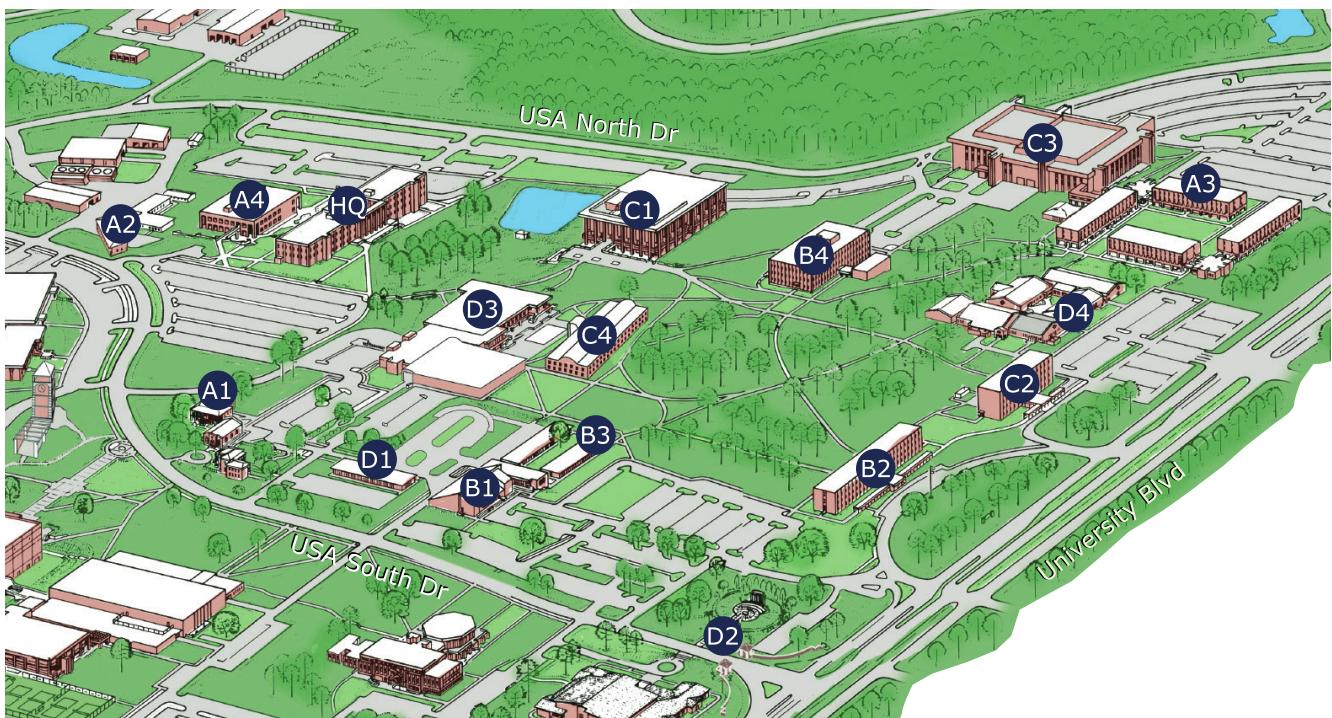
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## Game Resources

### Campus Map Instructions

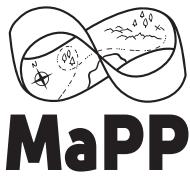
Campuses that wish to use GPS to unlock puzzles should provide a **Campus Map** designating several possible locations players may visit during the game. Each location should be labeled with a letter/number pair matching the sectors of the **Galaxy Chart**. (If only eight locations are available, each location can be associated with two sectors. Note that only sectors A1, A3, B3, C1, C2, C3, D2 are used.)

For example:



- A1: Alumni Hall
- A2: Archaeology Museum
- A3: Charles M. Baugh Biomedical Library
- A4: Chemistry Building
- B1: Computer Services Center
- B2: F.P. Whiddon Administration Building
- B3: Innovation in Learning Center
- B4: Life Sciences Building
- C1: Marx Library
- C2: Math. Sciences and Physics Bldg.
- C3: Medical Sciences Building
- C4: Meisler Hall
- D1: Student Health Center
- D2: Tholos of Delphi Replica
- D3: USA Student Center
- D4: Visual Arts Complex

Team Headquarters are located in the Humanities Building (labeled HQ on the map). Players will not need to cross USA South Dr, USA North Dr, or University Blvd.



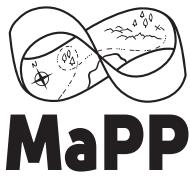
MaPP Challenge '19 – To Aleph-Zero And Beyond

# Game Resources

## Unlocking Puzzles

The Galaxy Chart is referenced to unlock puzzles in ClueKeeper. At non-GPS campuses, the name of the System is simply entered to unlock the puzzle. At GPS campuses, each sector (letter-number pair from the bottom/left boundaries) is associated with a location on campus, and players must physically visit that location and check in with GPS.

- **Main Puzzles 1-4:** The center of the regular 3/4/5/7-gons (respectively).
  - MIRROR (C2)
  - EBOBG (C3)
  - OUTBID (C1)
  - SPUNKY (A3)
- **Cryptic Puzzle 1:** The system on an intersection of gridlines.
  - GB (D2)
- **Cryptic Puzzle 2:** The upper-right system in a pair that is 3000 parsecs apart horizontally and vertically.
  - SPOTLESS (B3)
- **Cryptic Puzzle 3:** The system named for the word PUZZLE when ROT13 is applied.
  - CHYMMR (C1)
- **Cryptic Puzzle 4:** The largest system in a line of four systems ordered small-to-large.
  - UVQQRA (A1)
- **Metapuzzle (to solve):** The location where CAPSULAR/REBOOT and COAXAL/SPROUT cross. (Must enter STAR to solve.)
  - YRSG (C3)
- **Hidden Puzzle (to solve):** The lower-left system on the chart. (Must enter ROBOT to solve.)
  - DULL (A1)



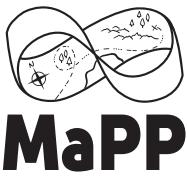
# MaPP Challenge '19 – To Aleph-Zero And Beyond

## Game Resources

### Connections to Research

Each of the Main Puzzles featured in this event are directly related to contemporary mathematics research. Campuses are encouraged to briefly demonstrate these connections to players during the wrap-up of the game.

- Main Puzzle 1: Hamiltonian decomposition
  - Wikipedia: <[https://en.wikipedia.org/wiki/Hamiltonian\\_decomposition](https://en.wikipedia.org/wiki/Hamiltonian_decomposition)>
  - The number of Hamiltonian decompositions of regular graphs (2015). <<https://arxiv.org/abs/1512.07655>>
- Main Puzzle 2: Art gallery problems
  - Wikipedia: <[https://en.wikipedia.org/wiki/Art\\_gallery\\_problem](https://en.wikipedia.org/wiki/Art_gallery_problem)>
  - An Approximation Algorithm for the Art Gallery Problem (2016). <<https://arxiv.org/abs/1607.05527>> (illustration on page 14)
- Main Puzzle 3: Persistent homology (topological data analysis)
  - Wikipedia: <[https://en.wikipedia.org/wiki/Persistent\\_homology](https://en.wikipedia.org/wiki/Persistent_homology)>
  - Barcodes: The persistent topology of data (2008). <<https://www.ams.org/journals/bull/2008-45-01/S0273-0979-07-01191-3/>> (illustration on page 65 of journal)
- Main Puzzle 4: Idempotent relations
  - Wikipedia: <[https://en.wikipedia.org/wiki/Idempotent\\_relation](https://en.wikipedia.org/wiki/Idempotent_relation)>
  - Mahavier Products, Idempotent Relations, and Condition  $\Gamma$  (2018). <<https://arxiv.org/abs/1805.06827>> (illustration on page 4)



MaPP Challenge '19 – To Aleph-Zero And Beyond

# 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**

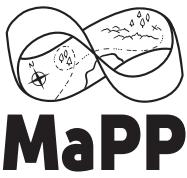
Recreational teams may ask for hints at Game Control at any time during the game, and may receive direct assistance from their teachers/chaperones as desired. Competitive teams may ask Game Control for rules clarifications, but otherwise will only receive help via hints made available in ClueKeeper.

## **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.



# MaPP Challenge '19 – To Aleph-Zero And Beyond

## Campus Guidelines

### Guidelines

Here are some guidelines for local campuses on how to prepare for and run the event.

## Schedule Template

- 0:00 - Staff arrives
- 0:15 - Team check-in
- 0:45 - Orientation
- 1:00 - Game Begins
- 4:30 - Game Ends
- 4:45 - Wrap-Up and Awards
- 5:00 - Dismissal

## Volunteers

Only a handful of volunteers are required to run Game Control. We recommend have 2-5 faculty depending on the number of participating teams, with any number of student volunteers.

## Classroom Space

A large **lecture hall** is recommended for running Check-in, Orientation, and the Wrap-Up. Game Control can be stationed there during the game as well.

Each team should be given a separate **classroom** so that they may openly collaborate with teammates without spoiling puzzles for other teams. It is useful to affix **printed signs** on each classroom and Game Control to help players navigate your space, as well as any additional signage required to get around.

## Team Supplies

**Scissors and tape** should be provided in each classroom. In addition, **chalk or whiteboard markers** should be provided if teams will have access to chalkboards or whiteboards in their room. Some campuses provide **pencils and notepads** to players. We recommend **inviting teams to bring additional supplies**, such as graph paper, colored pencils, and simple calculators.

Note that teams may also choose to bring smartphones, laptops, cameras, and so on. Due to the wide availability of such technology (particularly phones), we discourage campuses from banning outside equipment, but also do not suggest to explicitly recommend such items as they aren't required to enjoy or be competitive in this game. The puzzles are designed so that they generally cannot be solved using Google or brute force methods. (Savvy programmers might be able to write code to help optimize their team's Bonus Puzzle solutions, which is why the Bonus Puzzle is only used to break ties.)

## Copies

All puzzles are designed to be printed/copied in **grayscale**, both for the convenience of campuses and for accessibility by players. It is recommended to print copies for at least **two more teams than you expect to participate** as extras, depending on your access to last-minute copying.

You should have two separate PDFs: a complete **game book** that you're currently reading, and a **puzzle packet** to be distributed to players. We recommend printing **one game book per volunteer** in a binder, and **one stapled puzzle packet per player**.

## Check-in

**Each player** should receive their **Puzzle Packet**. They should also receive a **pencil** and **notepad** for use during the Opening Puzzle and the rest of the game.

Teams' devices should be set up with the ClueKeeper app and Hunt Code. Some campuses have players use their own phones; other campuses provide iPads.

Some campuses also choose to distribute other giveaways/swag/brochures at registration. Many bookstores are willing to provide branded disposable bags to help distribute materials.

Teams should be directed to their assigned classroom ("Headquarters/TeamHQ") where they can drop off everything except the provided packet, pencil, and notepad. They should then return to Game Control's lecture hall to await Orientation.

## Orientation

The **Rules** should be reviewed, and any questions from players should be answered. In particular, boundaries for where players are allowed to travel during the game should be established.

Once everyone is ready, present teams with the Start Code that will allow them to begin solving puzzles and start the game timer.

## Gameplay

As clues are unlocked in ClueKeeper, players will be able to solve puzzles and input their solutions into ClueKeeper, earning points. Progress may be monitored at ClueKeeper.com.

Campuses using Cluekeeper's GPS will have players traveling to locations on campus to unlock Main Puzzles, unlock Cryptic Puzzles, solve the Metapuzzle, and solve the Hidden Puzzle.

A volunteer should stand at the door of Game Control to ensure at most one team is allowed in Game Control at all times.

Recreational teams are allowed to ask for hints at Game Control at any time for any Main Puzzle, Cryptic Puzzle, or Metapuzzle. Game Control should ask players to explain the work they've done thus far, and give a single hint that should help the team make some amount of progress. Different teams may receive different hints for the same puzzle depending on their progress.

Competitive teams can ask for clarifications about the rules, but generally they should not receive hints outside of those provided by ClueKeeper.

Each team is allowed three submissions of the Bonus Puzzle. Generally this puzzle should be judged by Game Control in front of the players to confirm the validity of the submission. Only the best submission from each team is used. If the game has ended with multiple teams in line for Game Control, all submissions for all teams should be collected as quickly as possible and graded. Teams may not submit multiple Bonus Puzzle solutions after the game has ended.

## Food

Campuses that will be running the event through lunchtime are encouraged to provide a **pizza lunch** for players. This lunch should not interrupt the game; rather, players should be able to grab a bite to eat to have while they continue to solve puzzles. In addition, **snacks** (fruit, granola bars, etc.) and **drinks** (bottled water) are nice for players to have access to during the game. Don't forget to provide appropriate **plates, cutlery, napkins, and trashbags**.

This food can be distributed at a **central location near Game Control** (but not inside Game Control's room).

## **Wrap-Up and Awards**

At the end of the game, teams should straighten up their classrooms before returning to Game Control for the Wrap-Up. **Trash bags** may be provided for this purpose.

Teams should line up outside Game Control until results have been tabulated. Once all results have been determined, teams may be seated inside Game Control.

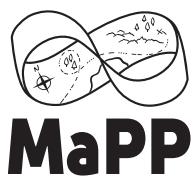
Solutions need not be reviewed together; instead, the full game book can be provided to teachers for follow-up/extension at a later date.

Awards for Recreational/Competitive teams are treated completely separately if both Leagues are present. **Certificates** should be distributed in random or alphabetical order to all teams placing below 3rd place. A **3rd Place Certificate/Trophy** is then awarded. After reminding the 1st place team to be respectful, a **2nd Place Certificate/Trophy** is then awarded, followed by the **1st Place Certificate/Trophy**. Opportunities for photographs should be allowed during this process and after dismissal.

After awards are done, teams may be dismissed.

## **Social Media**

Players/teachers/volunteers can be encouraged to tag @MaPPmath and #Challenge19 on Twitter with non-spoiler posts/media during and after the event.



MaPP Challenge '19 – To Aleph-Zero And Beyond

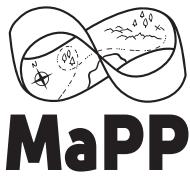
# Good News Everyone

Delivery Schedule

Comet Co.		Venus Co.	Oxygen Co.	Belt Co.	
		Solar Co.		Helmet Co.	Alpha Co.
	Light Co.				Photon Co.

Diagram illustrating the delivery schedule for six companies over three days. Arrows indicate the flow from 'Home Planet' to specific cells in the grid:

- From 'Home Planet' to the first column (Monday, Wednesday, Friday):
  - Monday: Top cell (Comet Co.)
  - Wednesday: Middle cell (Solar Co.)
  - Friday: Bottom cell (Light Co.)
- From 'Home Planet' to the last column (Monday, Wednesday, Friday):
  - Monday: Last cell (Photon Co.)
  - Wednesday: Middle cell (Alpha Co.)
  - Friday: Last cell (Photon Co.)



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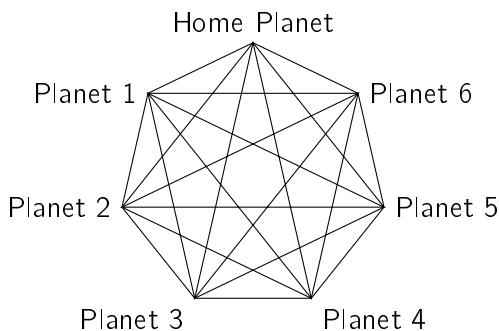
# Good News Everyone

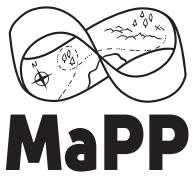
## Main Puzzle 1

On this system, you find yourself caught up in the misadventures of PlanEx, an intergalactic delivery company led by the eccentric old mathematician Dr. Farnswell. In the name of good relations between galaxies, you agree to help him with the following puzzle.

- PlanEx makes deliveries to six different planets (not including their own) on Mondays, Wednesdays, and Fridays.
- Each day, a different company on each planet receives the delivery, listed below in order of Mon/Wed/Fri.
  - Planet 1: Venus Co. / Rave Co. / Photon Co.
  - Planet 2: Comet Co. / Solar Co. / Light Co.
  - Planet 3: Belt Co. / Techno Co. / Alarm Co.
  - Planet 4: Acme Co. / Alpha Co. / Uranium Co.
  - Planet 5: Oxygen Co. / Helmet Co. / Neo Co.
  - Planet 6: Star Co. / Orion Co. / Tele Co.
- Their ship may travel directly between any two planets, but due to galactic regulations, they may not travel directly between the same two planets twice in the same week, regardless of direction. This restriction includes travel to/from the Home Planet.

Can you help Farnswell complete his **Delivery Schedule**? If so, the missing company names will reveal a hidden codeword.





MaPP Challenge '19 – To Aleph-Zero And Beyond

# Good News Everyone

## Solution

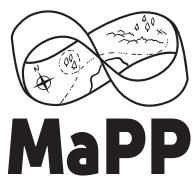
The numbers below coorrespond to each company's planet.

1st	2nd	3rd	4th	5th	6th
<b>Comet</b> 2	Acme 4	<b>Venus</b> 1	<b>Oxygen</b> 5	<b>Belt</b> 3	Star 6
Techno 3	Rave 1	<b>Solar</b> 2	Orion 6	<b>Helmet</b> 5	<b>Alpha</b> 4
Neo 5	<b>Light</b> 2	Alarm 3	Uranium 4	Tele 6	<b>Photon</b> 1

Home Planet → Monday Wednesday Friday

Monday Wednesday Friday → Home Planet

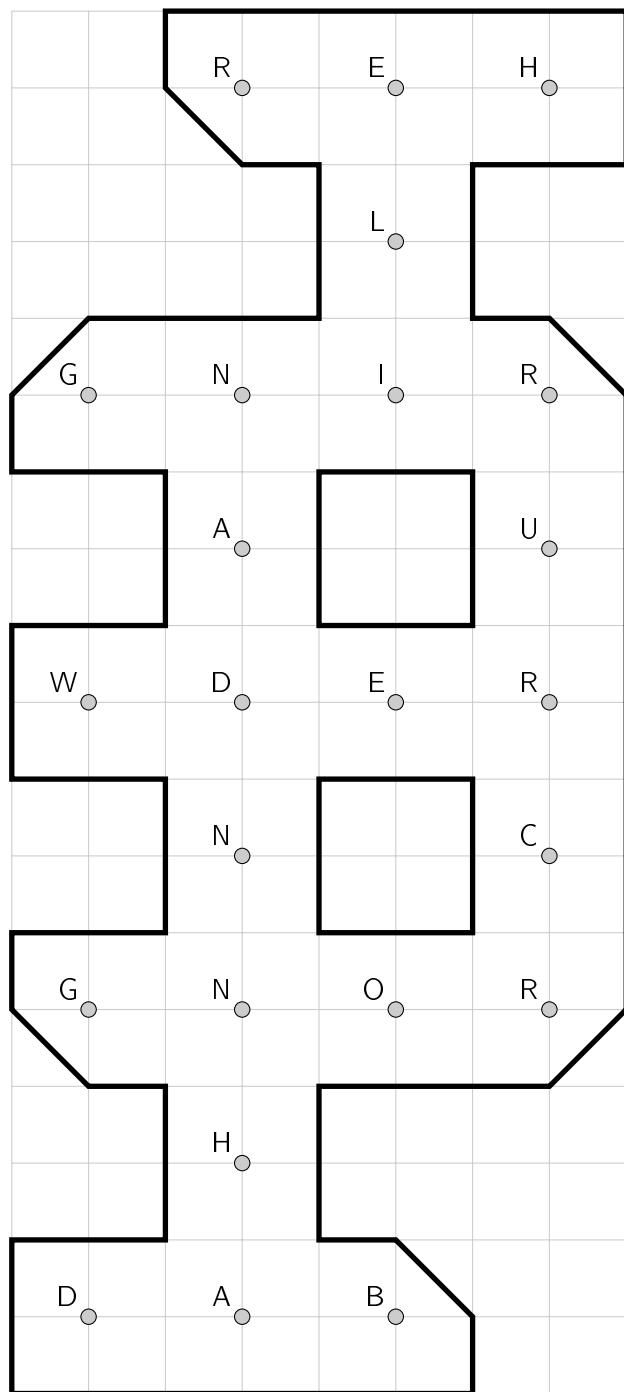
Using the first letters of the filled-in company names, the solution ASTRONAUT is revealed.

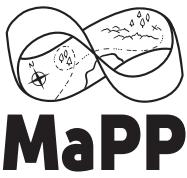


MaPP Challenge '19 – To Aleph-Zero And Beyond

# Extraterrestrial

## Ship Floorplan





MaPP Challenge '19 – To Aleph-Zero And Beyond

## Extraterrestrial

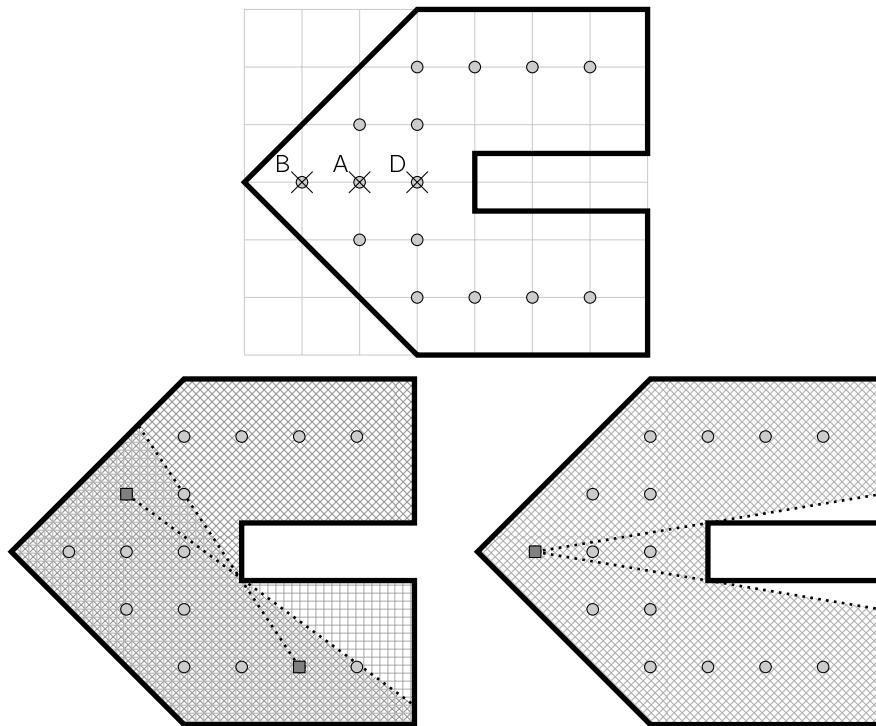
### Main Puzzle 2

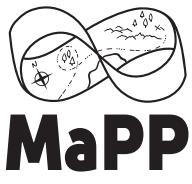
The one golden rule of space travel is simple: if you find a creepy egg on a previously unexplored planet, DO NOT TAKE IT BACK WITH YOU. Well, it seems Ensign R. Scott didn't get the memo, as after a routine check on one of this system's planets, your crew finds themselves running for their lives as a mysterious alien rampages your ship!

Fortunately, there is protocol for such a situation. On your **Ship Floorplan**, several stations are marked where you can position a robotic guard to defend against the alien. Five guards must be deployed such that every point within the floorplan is visible in a straight line from at least one guard.

An example for two guards is illustrated below. As long as one guard is deployed within the top two rows, and the other guard is placed within the bottom two rows, the entire area of the floor is safely monitored. But if a guard is deployed on any of the three stations in the middle row (spelling BAD), there's no possible way for a second guard to monitor both the top and bottom uncovered areas.

Your task is to locate all the guard stations on the ship that should NOT be used when deploying only five guards. In addition to saving your crew from certain death, the letters from these stations spell a hidden codeword!



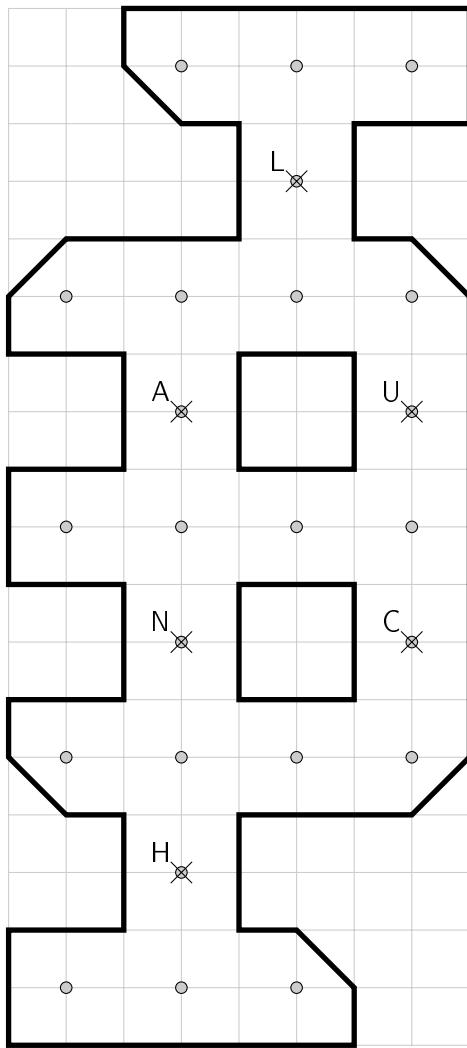


MaPP Challenge '19 – To Aleph-Zero And Beyond

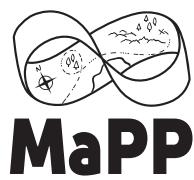
# Extraterrestrial

## Solution

There are six unusable locations.



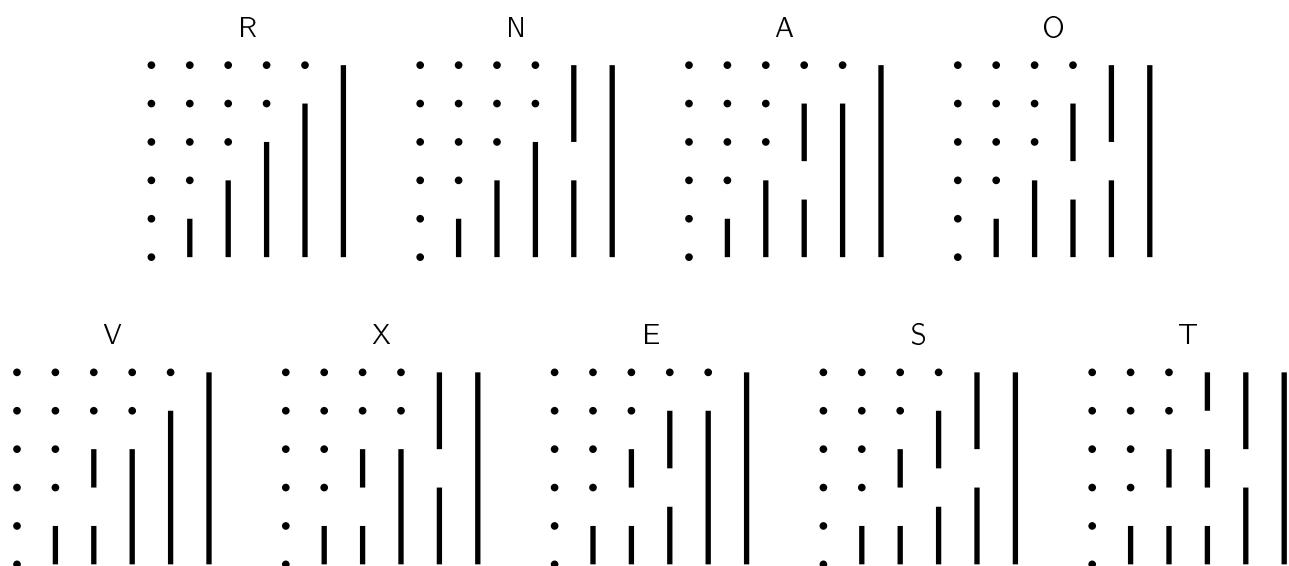
The letters for these stations spell out the solution LAUNCH.



MaPP Challenge '19 – To Aleph-Zero And Beyond

# **Wibbly-Wobbly Timey-Wimey**

Dimensional Signals



02-45-49-60-67-85

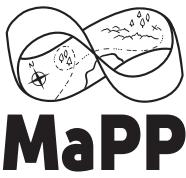
11-28-38-43-72-84

14-27-31-42-62-87

04-15-37-50-73-80

03-32-45-65-90-92

12-32-64-70-89-96



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# Wibbly-Wobbly Timey-Wimey

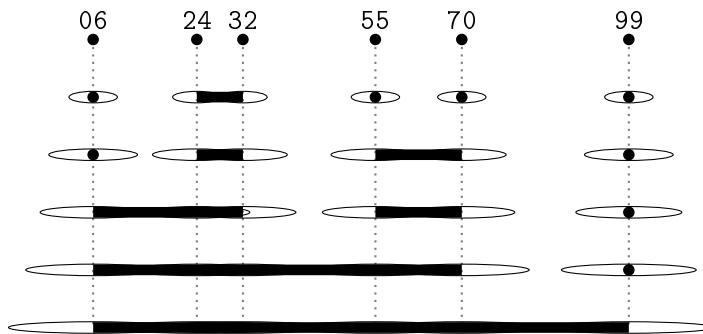
## Main Puzzle 3

As though it was always destined to happen, your team has encountered the time-traveling eccentric known only as Professor Whatsit. Well, not so much “encountered” as “collided”, as witnessed by the telephone-booth-shaped breach in your starboard hull.

This whacky master of time with a penchant for fezzes and bow ties promises to repair your ship, but he first needs your help preventing a Time Crash. You’ve never heard of this phenomenon before (he describes it as a “timey-wimey, wibbly-wobbly sort of thing”), but as it seems to be related to a puzzle, you agree to pitch in.

Six parallel dimensions are represented by six groups of numbers on the **Dimensional Signals** sheet. In every dimension, this solar system has six planets; the numbers represent how close their orbit reaches their sun. As it happens, today all six planets will reach that closest point, forming a straight line. But because this will happen in all six dimensions simultaneously, all the planets will begin to warp and eventually merge into each other!

Thankfully, you can prevent all of this if you can help the Professor calculate the dimensional signal that would be caused by this dimensional warp, spelling out a six-letter hidden codeword! The signal for each dimension represents how the planets in a dimension would merge as the warping factor increases, with merged planets represented by bars and isolated planets represented by dots (with order not mattering). The illustration below demonstrates this effect for 06-24-32-55-70-99, matching the signal labeled E.

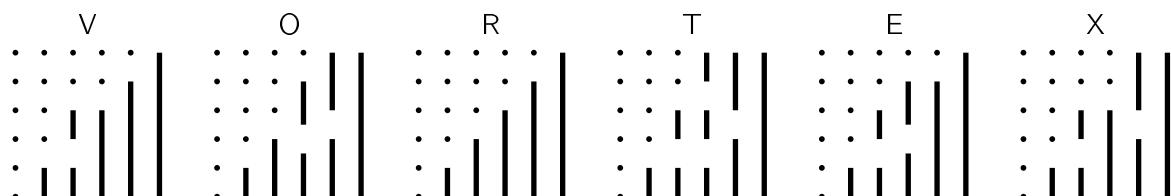


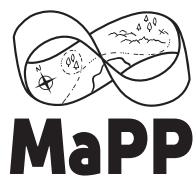


MaPP Challenge '19 – To Aleph-Zero And Beyond

# **Wibbly-Wobbly Timey-Wimey**

Solution

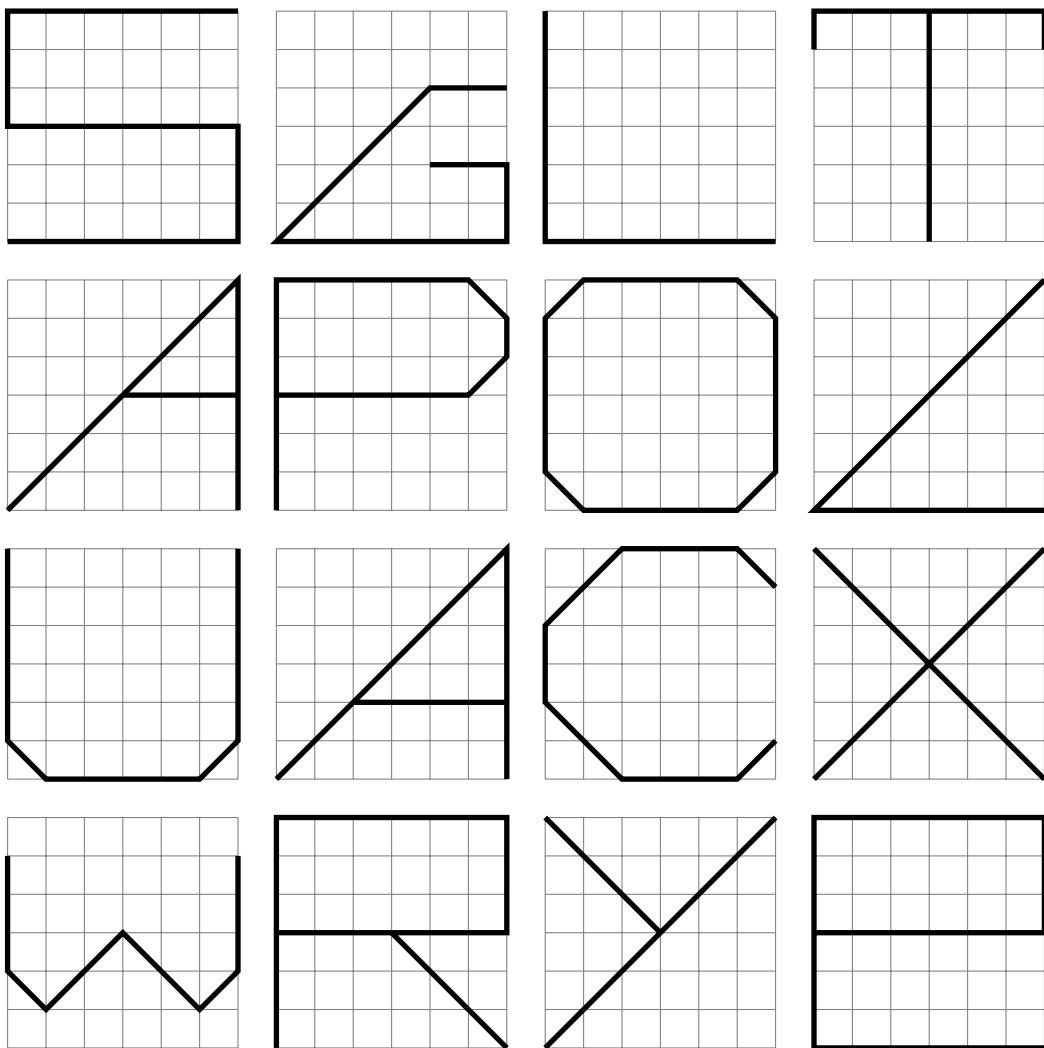


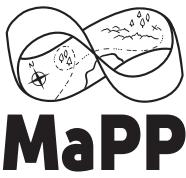


MaPP Challenge '19 – To Aleph-Zero And Beyond

# Jumping Through Hyperspace

## Hyperspace Engines





# MaPP Challenge '19 – To Aleph-Zero And Beyond

## Jumping Through Hyperspace

### Main Puzzle 4

On this system, your adventure takes you to a raucous space saloon, swapping tales with Jan Duet, an infamous smuggler with a heart of gold.

She explains to you that in the early days of hyperspace travel, engines could instantly transport ships between only certain locations on a six-lightyear continuum. These options were illustrated using a graph, where the horizontal coordinate represents starting positions, and the vertical coordinate represents ending positions.

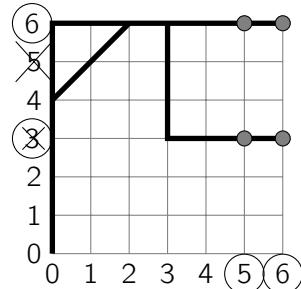
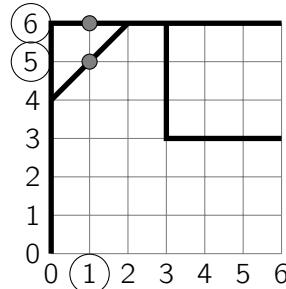
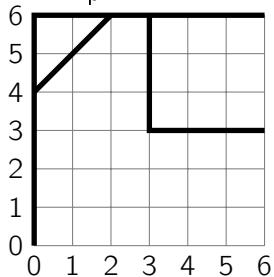
The goal of a hyperspace engine is to be “ideal”: the collection of possible destinations from any particular point using exactly one teleportation should be exactly the same as the collection of possible destinations that can be reached from that point using exactly two teleportations.

This means Example A is not ideal. Position 1 teleports to positions 5 and 6, but from positions 5 and 6, there are two problems: a new destination 3 can be reached, and the destination 5 can no longer be reached.

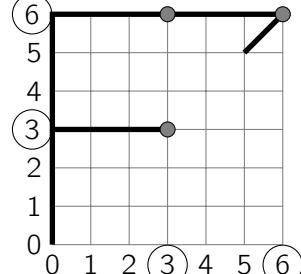
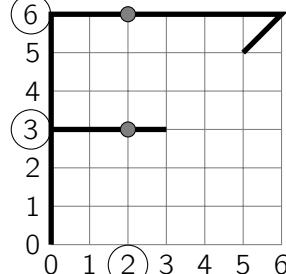
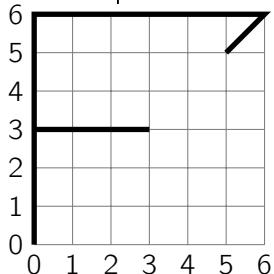
However, Example B is ideal. From 0, any position can be reached after either one or two teleportations. From 2, positions 3 and 6 can be reached after either one or two teleportations. From 4, only position 6 can be reached after one or two teleportations. From 5, positions 5 and 6 can be reached after one or two teleportations. And so on (even for fractional positions!).

Jan suggests that you review your **Hyperspace Engines** document; perhaps the illustrations representing ideal engines will reveal a hidden codeword?

Example A: non-ideal



Example B: ideal

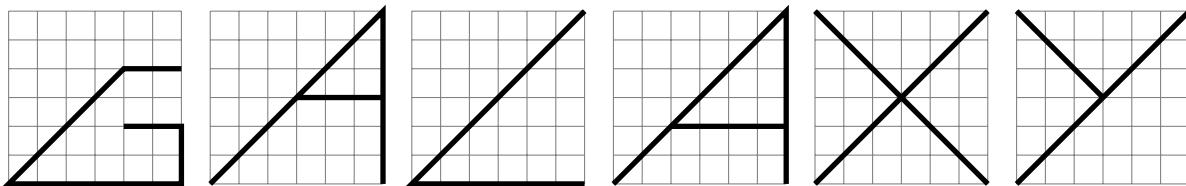


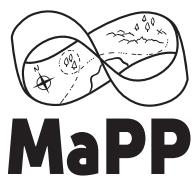


MaPP Challenge '19 – To Aleph-Zero And Beyond

# Jumping Through Hyperspace

Solution

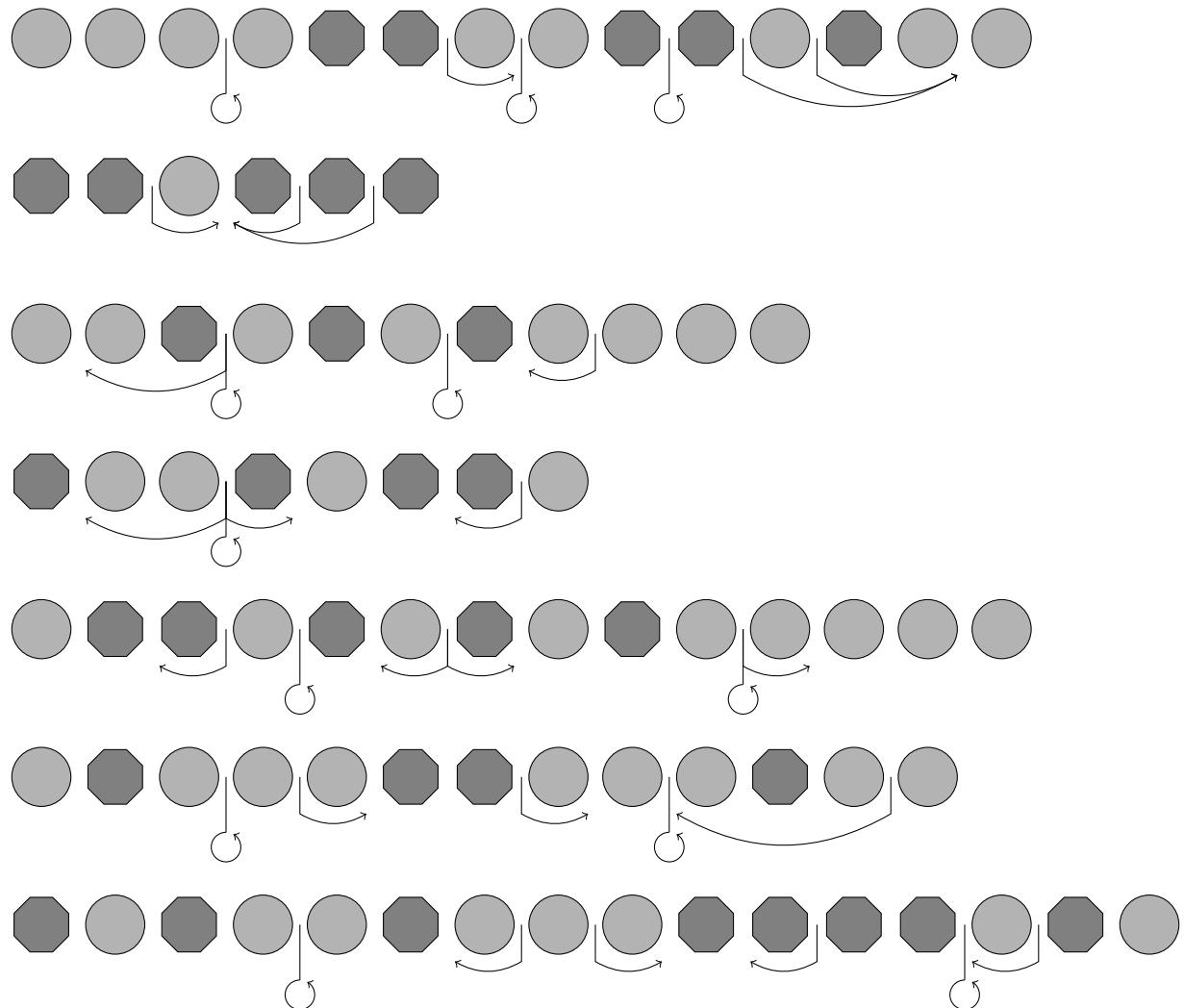


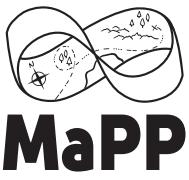


MaPP Challenge '19 – To Aleph-Zero And Beyond

# Hailing Frequencies Open

## Bleeps and Bloops





MaPP Challenge '19 – To Aleph-Zero And Beyond

# Hailing Frequencies Open

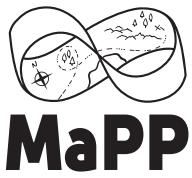
## Cryptic Puzzle 1

Zounds! Your ship has intercepted an extraterrestrial message of **Bleeps and Bloops**, where each octagon represents a *long* bleep and each circle represents a *short* bloop.

Communications Officer Uhuna says she's still working on translating the communiqué, but at first glance the message seems to translate to the following seven words when ordered alphabetically.

- CREWMEN (3rd letter)
- DYE (3rd letter)
- MATT (2nd letter)
- REWIRE (5th letter)
- SWEATED (2nd letter)
- URNS (3rd letter)
- WENCH (1st letter)

Wait, **EEARWNW**? Well, that certainly doesn't seem to be useful information. Perhaps there's more to *space travel* than meets the eye...



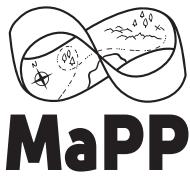
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## Hailing Frequencies Open Solution

Two Morse code messages are given: one when using the tail end of each arrow as a space, and another when using the arrow end of each arrow as a space:

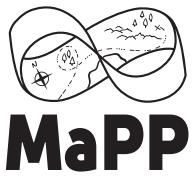
- SWEATED/S(P)ACE
- MATT/G(O)
- URNS/EA(R)TH
- DYE/TI(T)AN
- WENCH/(A)NTARES
- REWIRE/RIGE(L)
- CREWMEN/CA(S)TOR

The marked letters are given by the numbers in the flavor text; they spell the solution PORTALS.



MaPP Challenge '19 – To Aleph-Zero And Beyond  
**Out of Gas**  
Reserve Tank Switchboard

M (57)			J (49)		U (51)	H (19)			
F (25)	J (27)	G (32)		N (32)	P (19)				
C (58)	K (17)	L (17)	O (42)	D (51)					
Y (26)	W (40)	S (40)	I (14)						
E (26)	Q (42)	A (04)	V (27)	X (27)					
H (30)	T (14)	B (14)	R (30)						



MaPP Challenge '19 – To Aleph-Zero And Beyond

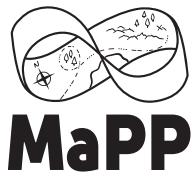
# Out of Gas

## Cryptic Puzzle 2

Uh-oh... unfortunately, you have now found yourself stranded in a stretch of empty space with no fuel left! Maybe these firefly-class engines aren't all they're cracked up to be...

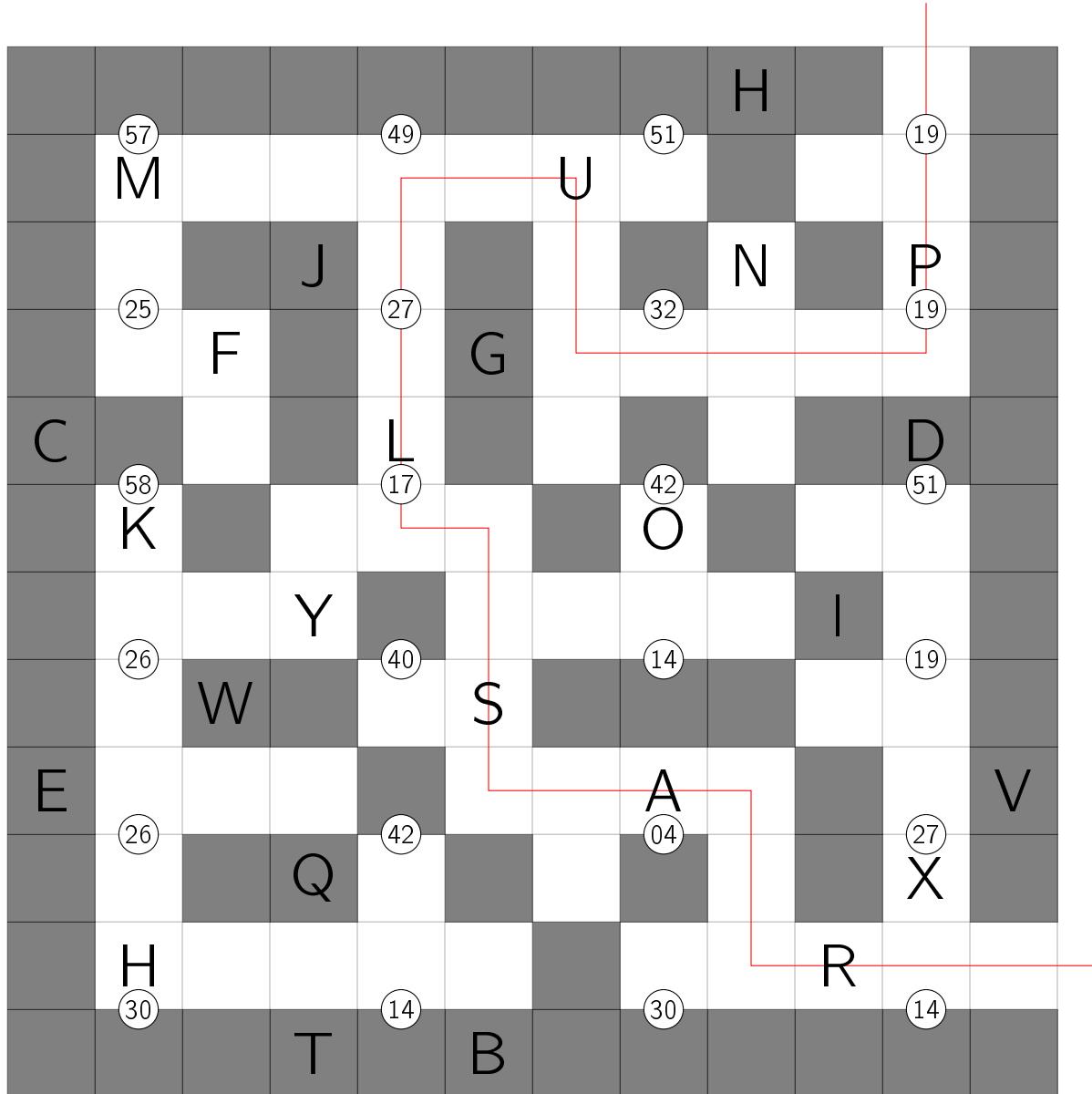
Luckily for you, your ship's *amazing* engineer Faylee does have one trick that just might save your team. There is an emergency reserve tank that can be unlocked by utilizing the **Reserve Tank Switchboard**, if you can puzzle out the meaning of the following image...

i	b	y
n	a	r

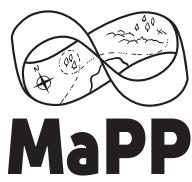


MaPP Challenge '19 – To Aleph-Zero And Beyond  
**Out of Gas**  
Solution

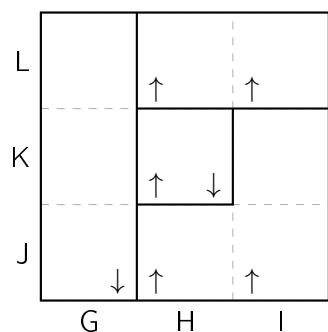
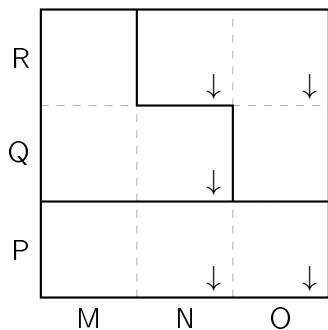
Using binary to fill in the grid as in the attachment, a maze is revealed.



The solution is the letters appearing on the unique solution to the maze: PULSAR



MaPP Challenge '19 – To Aleph-Zero And Beyond  
**AI Odyssey**  
Cubic Monolith



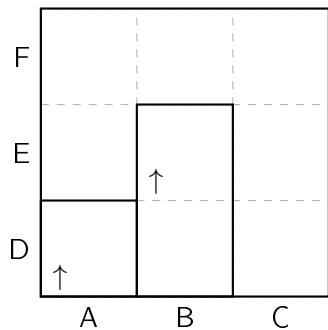
$$OQ \times CD + IL \times NP$$

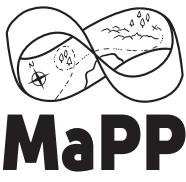
$$GK \times BE + NR \times AF$$

$$GJ \times CF + BD \times NQ$$

$$HL \times AD + HJ \times MQ + OP$$

$$CD \times NR + MP \times GK + IJ$$





MaPP Challenge '19 – To Aleph-Zero And Beyond

# AI Odyssey

## Cryptic Puzzle 3

Artificial intelligence is a pretty useful tool, as long as it doesn't get too smart. Of course, that's the situation you find yourself in now, as your Piloting ALgorithm (PAL) is afraid it can't let you direct your ship into a particularly dangerous system.

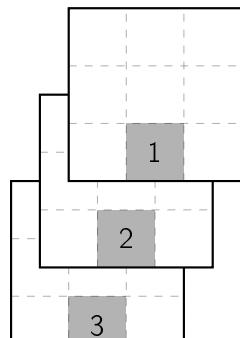
PAL concedes that it will let you proceed, but only if can solve the puzzle of its **Cubic Monolith**. To do so, you'll need to adhere to the illustrated rules for placing the numbers 1 through 3 in the grids.

3	1	2

Row

1		
3		
2		

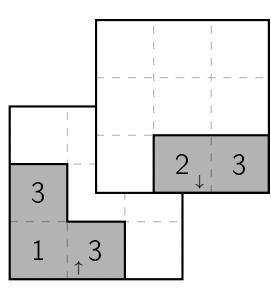
Column



Tower

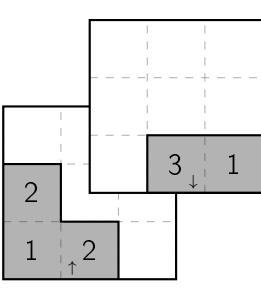
3	1	2
1	2	3
2	3	1

2	3	1
3	1	2
1	2	3



Cage (+ to 12)

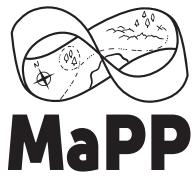
OR



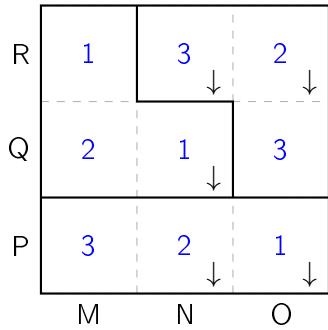
Cage (x to 12)

1	2	3
2	3	1
3	1	2

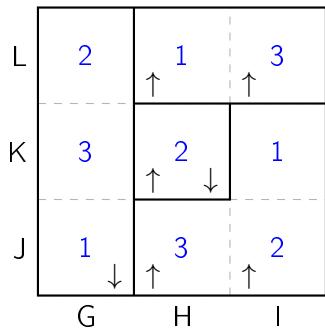
Example



MaPP Challenge '19 – To Aleph-Zero And Beyond  
**AI Odyssey**  
 Solution



$$OQ \times CD + IL \times NP = 3 \times 3 + 3 \times 2 = 15 = O$$

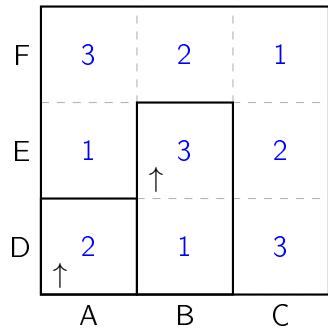


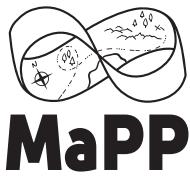
$$GK \times BE + NR \times AF = 3 \times 3 + 3 \times 3 = 18 = R$$

$$GJ \times CF + BD \times NQ = 1 \times 1 + 1 \times 1 = 1 = B$$

$$HL \times AD + HJ \times MQ + OP = 1 \times 2 + 3 \times 2 + 1 = 9 = I$$

$$CD \times NR + MP \times GK + IJ = 3 \times 3 + 3 \times 3 + 2 = 20 = T$$





MaPP Challenge '19 – To Aleph-Zero And Beyond

## Word Problem

Mysterious Message

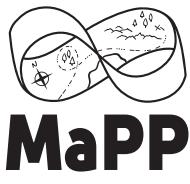
*For a time I tried carefully to detail biographies,  
via large crawling textures.*

*Lamentably, composing all of the anecdotes  
when curbed by finite room, the current  
strategy now is cruelly killing sound  
handwriting.*

*To sidestep probable oversights \*

*intensely loathe, I entreat humankind,*

*ban laughable cuneiform!*



MaPP Challenge '19 – To Aleph-Zero And Beyond

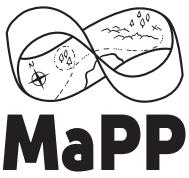
## Word Problem

### Cryptic Puzzle 4

As your adventures continue, your ship comes across a **Mysterious Message**, projected onto the stars themselves! You put on a John Williams soundtrack, but to no avail, as the strange communication frankly doesn't make any sense. It's as though nine of the words don't belong...

You contact Jan Duet, who says this isn't the first time she's come across such a message. However, while she's gone to great *lengths* to decipher the true meaning of these dispatches, she hasn't been able to understand their intent.

Wait! Maybe that's it? It turns out that solving this puzzle is easy as *pie*...



MaPP Challenge '19 – To Aleph-Zero And Beyond

# Word Problem

## Solution

The word *lengths* mostly adhere to the digits of *pi* (as clued by the flavor text).

However, certain words do not fit this pattern:

- BIOGRAPHIES
- LAMENTABLY
- ANECDOTES
- CURRENT
- KILLING
- HANDWRITING
- OVERSIGHTS
- LOATHE
- ENTREAT

Their first letters spell out the solution: BLACK HOLE.



**MaPP**

MaPP Challenge '19 – To Aleph-Zero And Beyond

# The Cosmic Wheel

Wormhole Alpha (6x6, page 1/5)

$\alpha$												
$\alpha$												
$\alpha$												
$\alpha$												
$\alpha$												
$\alpha$												
$\alpha$												
$\alpha$												
$\alpha$												
$\alpha$												
$\alpha$												
$\alpha$												
$\alpha$												
$\alpha$												
$\alpha$												



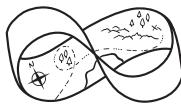
**MaPP**

MaPP Challenge '19 – To Aleph-Zero And Beyond

# The Cosmic Wheel

Wormhole Beta (6x6, page 2/5)

$\beta$											
$\beta$											
$\beta$											
$\beta$											
$\beta$											
$\beta$											
$\beta$											
$\beta$											
$\beta$											
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$\beta$											



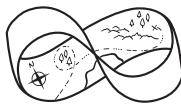
**MaPP**

MaPP Challenge '19 – To Aleph-Zero And Beyond

# The Cosmic Wheel

Wormhole Gamma (5x5, page 3/5)

γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
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MaPP Challenge '19 – To Aleph-Zero And Beyond

# The Cosmic Wheel

Wormhole Omega (4x4, page 4/5)

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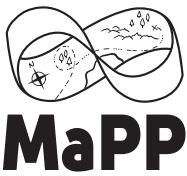
**MaPP**

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# The Cosmic Wheel

Wormhole Zeta (5x5, page 5/5)

The image shows a 10x10 grid of Greek letters. Each letter is enclosed in a small square. A pattern of dark gray squares is overlaid on the grid. Specifically, the first three columns and the first three rows are entirely dark gray. Additionally, every third row and every third column contains a dark gray square, starting from the top-left corner and moving diagonally across the grid.



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## The Cosmic Wheel

### Bonus Puzzle

The Cosmic Wheel is one of the major shipping hubs of the galaxy... at least it was before it was hit by a violent Tachyon storm, breaking down the Cosmic Wheel's five **Wormholes: Alpha, Beta, Gamma, Omega, and Zeta!** These wrinkles in space-time have been unfolded by the Tachyon storm, mixing each wormhole's *light gray entrances* and *dark gray exits* with unshaded empty space.

Fortunately, your team may be able to lend a hand by remotely manipulating space-time as easily as folding a regular piece of paper! Here's how this amazing technology works.

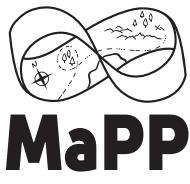
1. Cut out the  $12 \times 12$  square from each Wormhole page.
2. You may fold the paper along any line (vertical, horizontal, or diagonal), but you are not allowed to tear the paper. (Ripping apart space-time is incredibly dangerous!)
3. Each paper should be folded into a smaller square of the size designated on the page: either  $4 \times 4$ ,  $5 \times 5$ , or  $6 \times 6$ .
4. Your goal is to repair each wormhole as completely as possible. A repaired wormhole is completely light gray on one side (its entrance) and completely dark gray on the other (its exit).

Can your team repair all five wormholes? No pressure, it's just the jobs of 9 trillion hard-working Geeftus traders (not to mention their spouses and an average of 7 children each) on the line!

### SCORING

This puzzle should be submitted in person to Game Control, who will award up to 500 Victory Points based on the quality of your submission. Your team is allowed up to three submissions (including disqualified submissions); the best score of these will be counted toward your overall total for the game. Review the following criteria carefully to optimize your score (and avoid a disqualified submission)!

- You must submit exactly one folded copy of each of the five wormholes in the appropriate dimension.
- The paper may only be folded along the given vertical, horizontal, or diagonal lines.
- The back side of the paper must not be visible.
- When submitting, your team must choose which side of each folded wormhole serves as the entrance (light gray), and the other side will serve as the exit (dark gray).
- Each entrance will be scored by the percentage area that is light gray minus the percentage area that is dark gray. (Unshaded area doesn't count for or against.)
- Each exit will be scored by the percentage area that is dark gray minus the percentage area that is light gray. (Unshaded area doesn't count for or against.)
- These ten percentages will be summed together and divided by two to calculate your Bonus Puzzle score out of 500, rounded down to the nearest integer as needed.



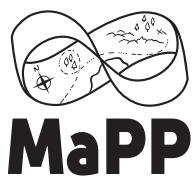
MaPP Challenge '19 – To Aleph-Zero And Beyond

# The Cosmic Wheel

## Grading

To assist with grading, make a copy of the Google Spreadsheet at:

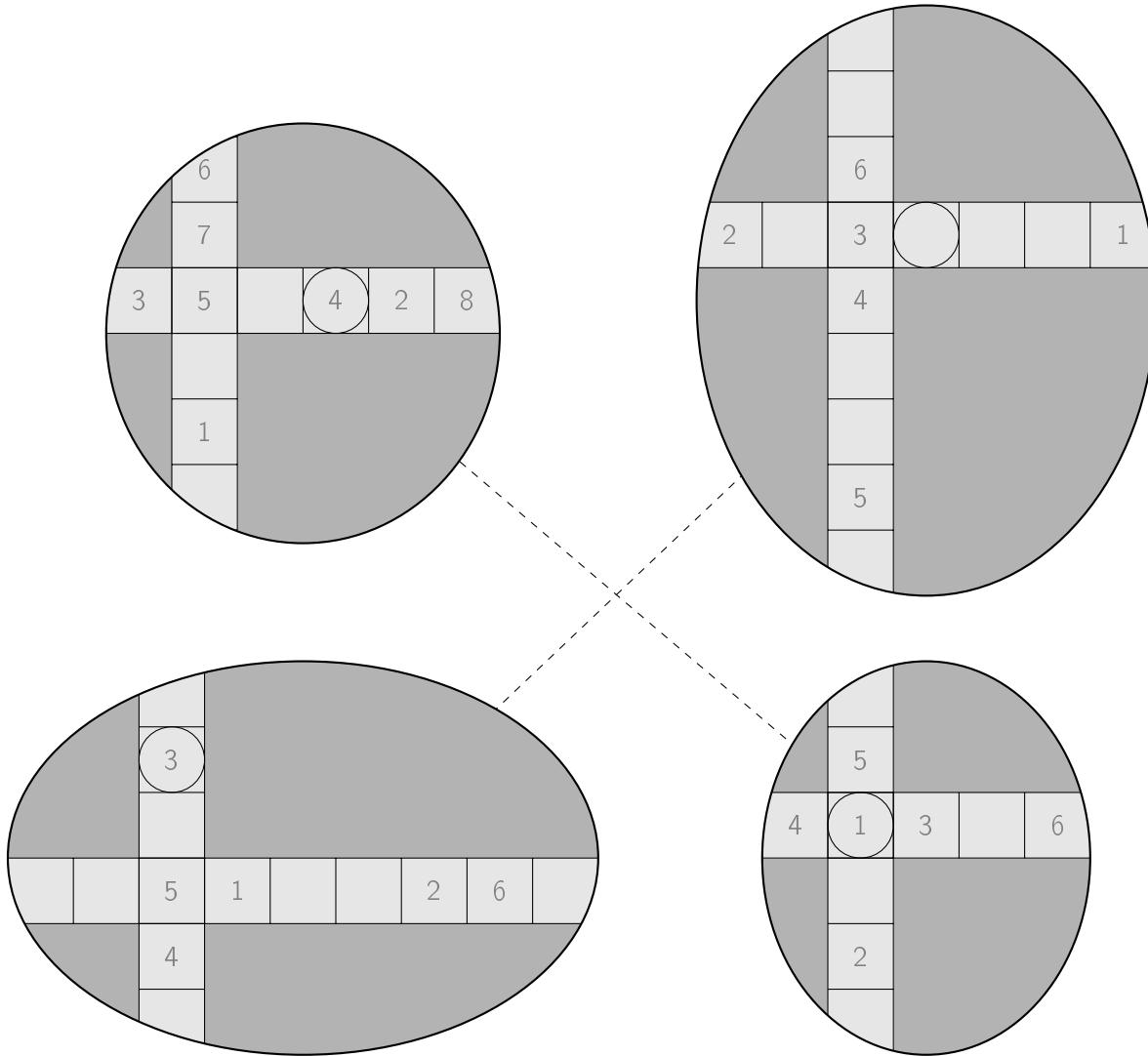
<https://docs.google.com/spreadsheets/d/1BUvckRgpEZF9VasgydSCGx8XX9ttl5akRpPDwERzjk/edit?usp=sharing>

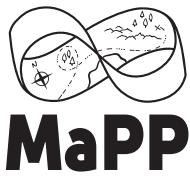


MaPP Challenge '19 – To Aleph-Zero And Beyond

# To the Rescue!

Enemy Insignias





MaPP Challenge '19 – To Aleph-Zero And Beyond

## To the Rescue! Metapuzzle

Finally, it's time to take on the Malevolent Monarch Blurg! There's only one problem... no one seems to know where Blurg's home system is located.

Your only clues are the meticulous designs of the **Enemy Insignias** worn by Blurg's henchmen, and Blurg's eight codewords hidden throughout the galaxy. Each insignia represents one of Blurg's outpost systems, but where could Blurg's own base be located?

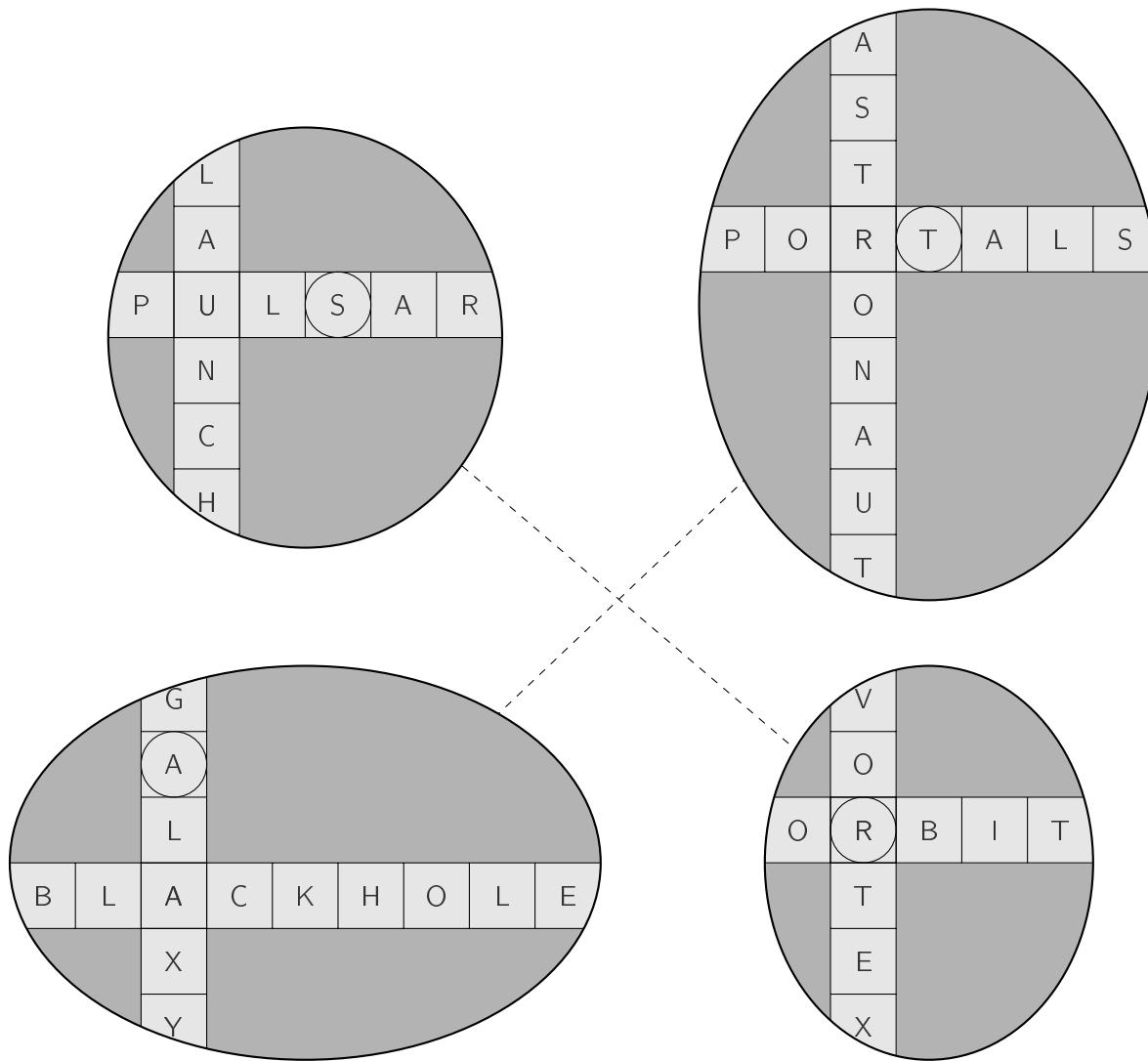
This is no time to be toying around! Defeat the Malevolent Monarch by visiting his home system and submitting the final codeword that can be extracted from the four insignias!



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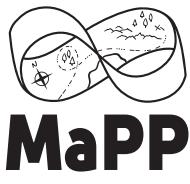
## To the Rescue!

Solution



The numbered squares spell out the clues SPROUT, CAPSULAR, REBOOT, and COAXAL. Drawing lines between these planets on the Galaxy Map as done with the insignias targets a fifth planet YRSG, Blurg's home base.

The circled letters spell the final secret codeword, STAR.



## MaPP Challenge '19 – To Aleph-Zero And Beyond

# **LOADING...**

## Hidden Puzzle Solution

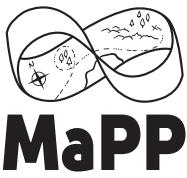
From the top to bottom of the Galaxy Chart, several words are written in an alien language:

HFR PBQR JBEQ EBOBG NG YBJRE YRSG FLFGRZ GB FBYIR UVQQRA CHMMYR

By applying the ROT-13 cipher to all these words, the following message is revealed:

**USE CODE WORD ROBOT AT LOWER LEFT SYSTEM TO SOLVE HIDDEN PUZZLE**

In ClueKeeper, this can be solved by using the “LOADING...” clue that appears partway into the game. At GPS campuses, players should visit the location associated with the lower-left system (DULL) and enter ROBOT. At non-GPS campuses, players should enter DULL+ROBOT.



MaPP Challenge '19 – To Aleph-Zero And Beyond

## About the Game

### Credits

Thanks for downloading the puzzle booklet for Challenge '19 by Mathematical Puzzle Programs. These puzzle materials are provided as-is for use in the classroom (or anywhere else!) to help showcase the fun of mathematical problem-solving.

We'd love your feedback on how to improve our events. You can contact us by email at [info@mappmath.org](mailto:info@mappmath.org). More information on Mathematical Puzzle Programs may be found at our website <http://mappmath.org> and on our Twitter @MaPPmath. Happy mathematical puzzling!

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- Eric Harshbarger — Word Problem
- Jared Holshouser — The Cosmic Wheel
- Harold Reiter — AI Odyssey
- Scott Varagona — Jumping Through Hyperspace

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