Rune Cube

by Kagen Sound

Background, Descriptions & Problems by John Rausch

2020

Background

The Rune Cube was designed and crafted by Kagen Sound. Kagen has developed puzzles using an underlying maze concept for many years. The best known of these are his Maze Burr, Rune Box, and Waterfall Boxes. The Rune Cube is the latest design evolved from the Beast, 83 Move Box, Waterfall Boxes, Rune Box, and Maze Burr. There were two versions of the Beast, neither released. It was the second puzzle box made by Kagen, following the Pinwheel. The 83-Move Box was released prior to 2002 and was similar to the Waterfall Boxes. Only two were made.

Rune Cube

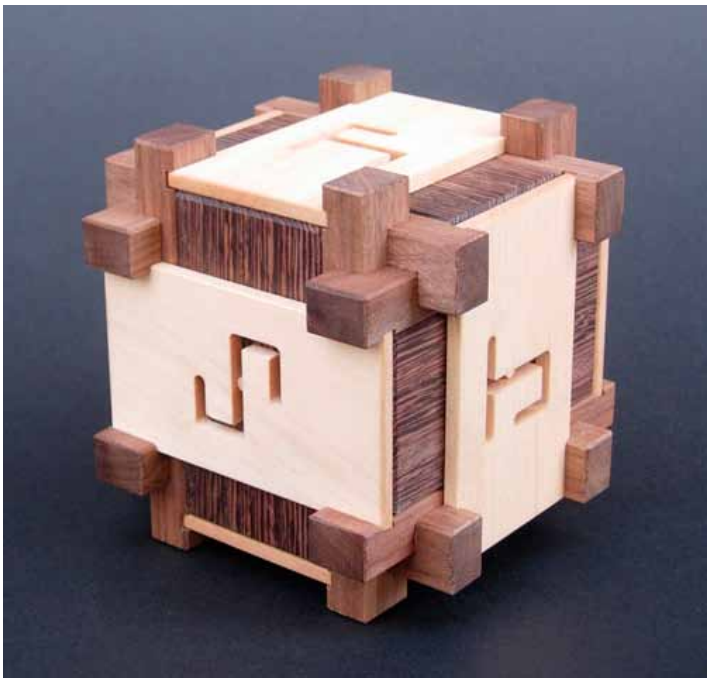
There are five different Waterfall Boxes, all having fixed internal mazes and released from 2002 through 2006. The number of moves increased for each Waterfall Box starting with 7, then 15, 19, 42, and 83. In 2015 a set of 5 Amboyna Waterfall Boxes was released.

42-Move Waterfall Box

The Rune Box was released in 2005. Unlike the Waterfall Boxes, the 6 sides of the Rune Box can be removed, then placed in different locations. Kagen provided a couple of hand-drawn problems with the Rune Box he found manually

Rune Box *Cocobolo*

Several editions of the Maze Burr were released starting in 2006. That year, it was awarded both the Grand Prize and People's Choice awards at the Nob Yoshigahara Puzzle Design Competition. The committee declared it "Puzzle of the Year". Subsequent editions incorporated several enhancements, but the puzzle aspect remained unchanged. Visit Kagen's web site for more information about all of these his puzzles at kagensound.com.



Maze Burr *1st Edition*

My involvement

I had one Waterfall box, and bought a Rune Box from Kagen in 2005. After a month or two, it occurred to me that a configurable maze design could be implemented with maze panels and peg panels on the sides of a frame like framed burr puzzles. I emailed Kagen in September 2005 and he replied that he already had a design like what I described. A flurry of over 100 emails were exchanged. I started working on a solver that would also work for the Rune Box, and the proposed Maze Burr, which had not been named at the time. From the beginning, Kagen considered it a drawback having to backtrack the solutions for the Rune Box and Maze Burr to get the mazes to their centered position. This was at least as difficult as taking them apart, therefore all of the Maze Burrs he released had this characteristic. Providing solutions for the problems made it fairly easy to backtrack, but it was unlikely the solution would be remembered when trying to solve it. But if you become totally confused, too bad, you have to solve it.

Kagen sent me a prototype with some exit mazes and non-exit mazes to experiment with. Numerous tests were made with different combinations. The solver allows up to 100 maze definitions and up to 15 can be selected at a time yielding millions of possible problems from the permutations and combinations. The PC hardware in 2005 took a day or more when 1 exit maze along with 10 non-exit mazes were selected for solving. The notched prototype frame sticks were square, with 10 identical and 2 with an extra notch allowing the next to last maze to be placed. Trying out some of the problems I had found, I discovered many could not be assembled because one of the notches on the 2 odd ones had to be longer. Kagen sent me 2 modified frame pieces, but what little wood remained to support the ends of the pieces was small and fragile already. Production Maze Burrs were made with rectangular frame pieces to overcome this.

Prototype Maze Pieces *Note the two modified sticks off to the right*

Prototype Maze Burr *Solved*

After many tests with the prototype mazes, I started trying mazes Kagen had not provided. One of the exit mazes yielded a problem with a 115-move solution and another resulted in the most number of moves found, 116. I think this is the limit, at least for configurations having 1 exit maze that moves first and is the only maze that can move first. Kagen made and sent these two exit mazes and a couple more non-exit ones.

He was not satisfied with the 116-move solution because it had an n-ary feel to it. The problem with a 113-move solution seemed to have no order or logic to it. Kagen considers the problem with 113 moves included in the instruction booklets one of the most confusing. The problem with a 115-move solution is very similar. It uses an exit maze resembling a question mark and had many more problems with random-like moves, so it and one other exit maze were selected for the set provided with the first Maze Burrs. Kagen and I selected the 10 non-exit mazes making up the set of 12.

Comparison of the Mechanisms

For the Rune Box, and all boxes before it, moving a panel moves the peg through a 3×3 maze hidden beneath the panel. The inlays on the Waterfall Boxes hint at the mazes, or have an inlay for the 83-move version. The runes (mazes) on the Rune Box panels are also for a 3×3 maze self-contained within the mechanism on the panel's back side. The Rune Box has a very clean look and the six panels do all of the blocking. After removal, the panels can rotated 180° for new configurations. They cannot flipped over (reflected).

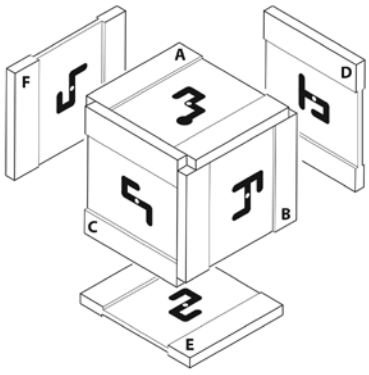
The mazes on the Maze Burr move back and forth lengthwise on the peg in the peg plate and the peg plates move the peg side to side in the maze, a mixed way of navigating the mazes. Both mazes and peg plates do the blocking. The mazes can be rotated and flipped over.

The Rune Cube returns to the clean Rune Box look and feel but with both the maze panels and the pegs visible. The mazes on Rune Cube can be rotated and flipped over. Like the Rune Box and Maze Burr, the letters A to F are used for the location of the panels or mazes, but locations are lettered differently for the Rune Cube.

The locations on the Rune Box and Maze Burr are:

A – Top
B – Right
C – Front
D – Left
E – Back
F – Bottom

The locations for the Rune Cube are:



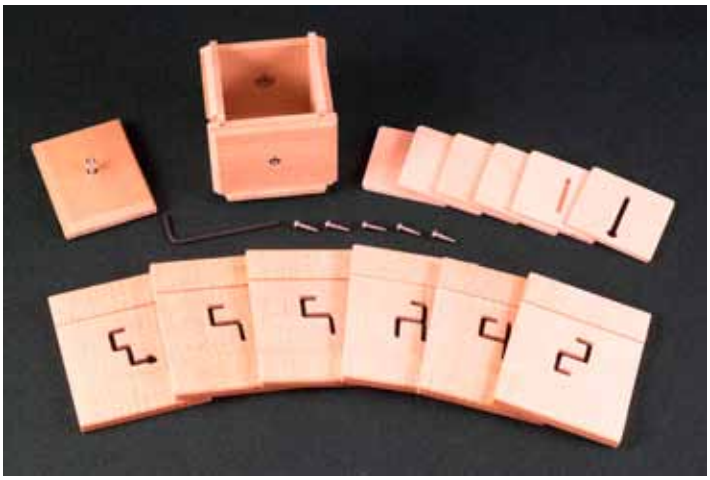
Rune Cube *Maze locations*

It would be fairly easy to glue up or print a core or box with 6 pegs sticking up in the center of each side, and make mazes. But there's an issue to deal with. If a maze is unblocked on all 4 sides, you can spin it around on the peg. Using a square peg would help some, but it would still twist and the peg might snap. At a segment junction the maze could still be twisted.

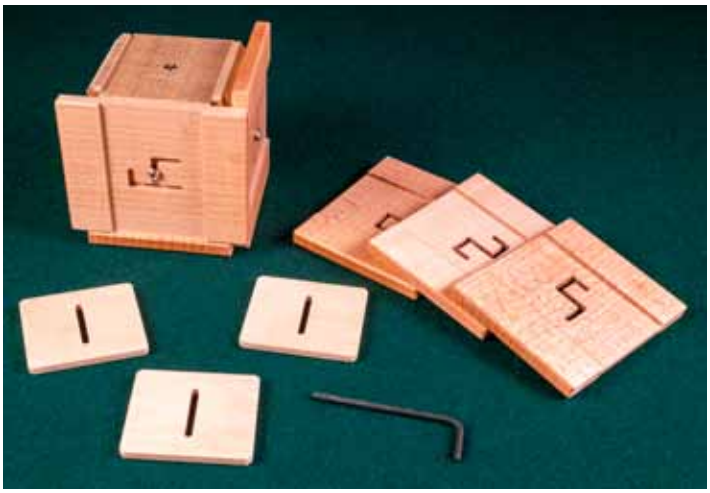
Kagen solved this by using a slotted plate he calls the "orthogonal plate". This plate fits in a recess on each face with sides that let it slide back and forth but prevent it from rotating. The mazes pieces have a centered recess on both sides. This recess rests on the orthogonal plate with the top and bottom edges permitting only left and right movement. The maze and the orthogonal plate are held in place with a small hex-head steel shoulder bolt going through the maze and the slot in the orthogonal plate.

This combination allows the mazes to move back and forth carrying the orthogonal plate with it and the peg (the shoulder bolt) riding in the slot. Because the maze sets higher than the sides preventing the orthogonal plate from twisting, the maze can shift left and right, sliding on the top and bottom edges of the orthogonal plate. For ease of reconfiguring, one orthogonal plate has a slot with a rounded end (like an elongated keyhole) that lets it slip over the head of the shoulder bolt. A hex key is provided for the shoulder Bolt.

The orthogonal plates will normally stay in place when reconfiguring the mazes



Rune Cube *Parts*



Rube Cube *Partially assembled*

The Solver

The Rune Box was released with a few hand drawn problems. The solver found that there are 960 configurations of the 6 panels, 563 of them with solutions ranging from 14 to 102 moves. The Maze Burr was released with a booklet having 30 problems. They were selected from 14.766,080 configurations, 8,723,152 with solutions found by the solver and ranging from 6 to 115 moves!

As previously mentioned, one exit maze not included has a problem with 116 moves. The Rune Cube includes only the 6 mazes required for the 115-move solution. By reducing the number of mazes from 12 (2 exit and 10 non-exit) to 6 (1 exit and 5 non-exit) it eliminates permutations yielding 24,202 solutions from 30,720 maze configurations. There are still more than enough problems to keep any puzzler busy for a lifetime.

The booklet Kagen included with the Rune Cube has 16 problems ranging from 6 to 115 moves. The number of moves required is shown, but not the solutions, They will probably be made available sometime after the edition sells out.

Using statistics from the solver I came up with way to identify problems with solutions that can very easily send you down a "fork in the road" to a dead end or a solution with many more moves than the minimum required. For example, there is one problem with 14 moves with at least 255 solutions greater the 14 moves. For 14 moves, you should be able to easily find the minimum solution once you are familiar with the how the mazes block and unblock. For the 25-move problem, things get more complicated. The solver cuts off the search at 255 moves.

I selected at least 1 problem for all of the 76 different number of moves from 6 to 115 and sent a few of them to Kagen. He included 7 of these "diabolical" problems on a separate foldout that does not show the minimum number of moves required. I have included the number of moves for the additional problems here, along with the ones from the foldout Kagen provided. You decide if you want to know. I think knowing the minimum number of moves gives you something to aim for.

On the following pages are 112 problems. Maze **A** is the top, **B** is the front, **C** is the left, **D** is the right, **E** is the bottom and **F** is the back. The problems show the maze pieces oriented as though the puzzle were made from paper and you unfolded it flat in front of you with piece **E**, the bottom, attached to piece **D**, the right. The 115-move problem is the one included with Kagen's booklet. It is here for completeness. Problems 33, 66, 88, 3, 59, and 96 are on the diabolical foldout. The last one is a variation of another 25-move problem I sent to Kagen.

Advantages of the Rune Cube

Size. The Rune Box is 5 ¼ inches in all dimensions, Maze Burrs vary slightly from around 4 to 4 ½ inches. Making moves on the Rune Box are unwieldy because it is large. Maze Burrs are better, but not ideal. The Rune Cube is 2 ¾ inches and very comfortable to manipulate.

Maze Movement. As moves are made on the Rune Box, the position of the peg in the maze (rune) is not easy to determine. The location of the panel is the best method and takes some getting used to. For the Maze Burr, the position is obvious, but moving mazes back and forth and peg panels side to side is a compromise to maze a puzzle less costly than the Rune Box.

Because the pegs (the shoulder bolts) are fixed and the mazes are visible on the Rune Cube, all moves are made with the mazes. It has the clean look and moves of the Rune Box with only maze panels on the sides.

The orthogonal plate provides friction to hold the mazes in place after moving them. It might appear that the shoulder bolts provide pressure to hold the mazes, but they don't. They bottom out on the embedded nut and prevent crushing the mazes. They touch the mazes, but mainly keep the mazes in place, not provide moving resistance. This is a significant improvement over the Maze Burr because it is annoying to have mazes slipping from where you want them as you move them around.

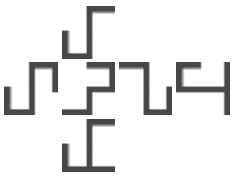
Reconfiguration. The Rune Box is easy to reconfigure, but the panels cannot be flipped over because the mazes and pegs are in an enclosure on the back of the panels. Reconfiguring the Maze Burr requires quite a bit of dexterity. The frame sticks are not fixed (except on a later box version) and can easily collapse. An owner *can* glue the sticks together, but I doubt anyone has.

The Rune Cube can be reconfigured in a few minutes. There is no reason to remove the orthogonal plates. They will stay put on the sides of the core.

See Kagen's web page for his photos and details at:

kagensound.com/RuneCube.html

Maze Locations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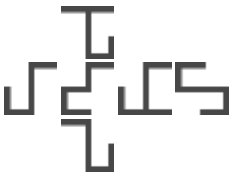
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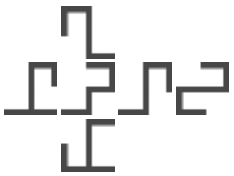
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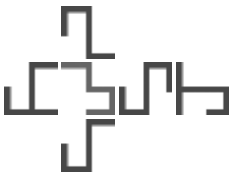
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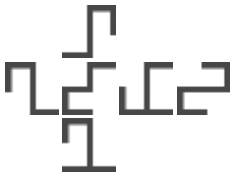
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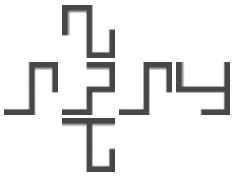
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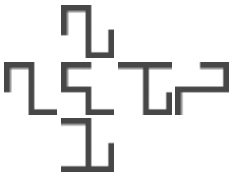
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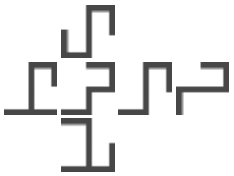
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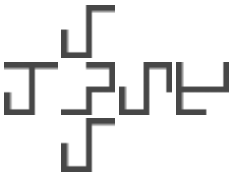
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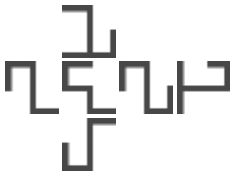
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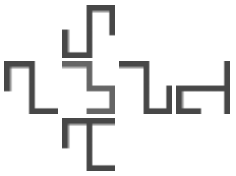
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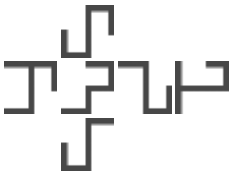
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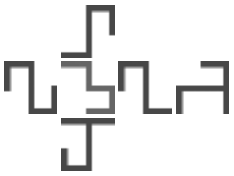
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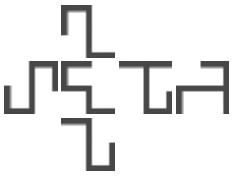
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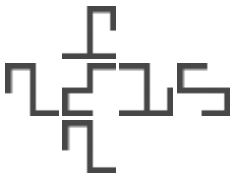
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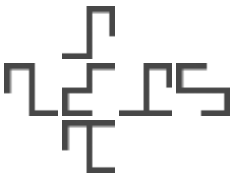
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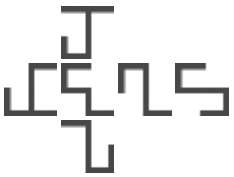
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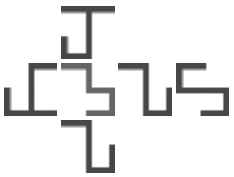
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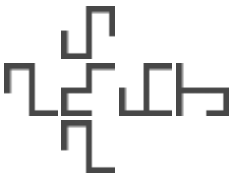
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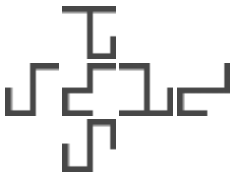
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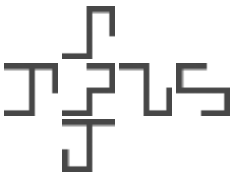
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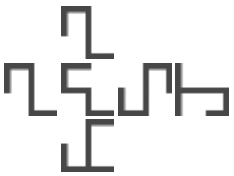
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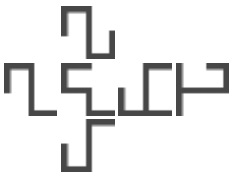
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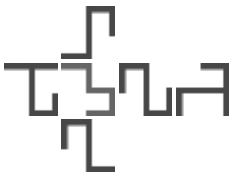
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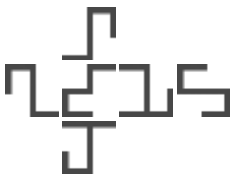
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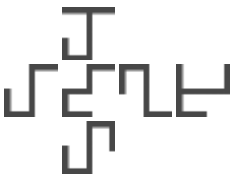
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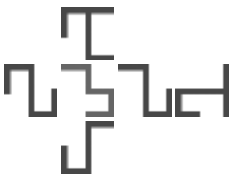
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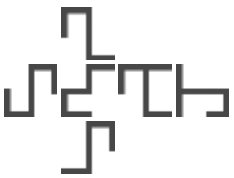
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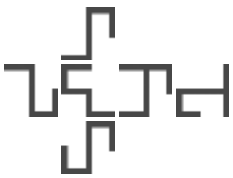
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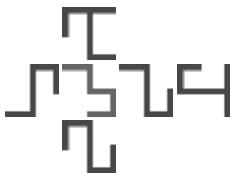
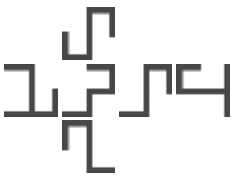
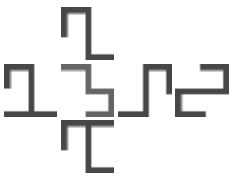
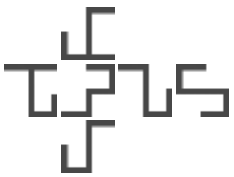
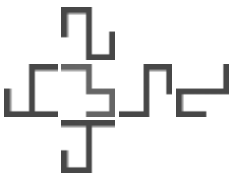
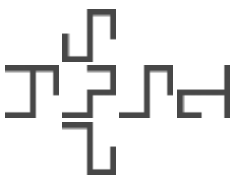

30 - 32 Moves

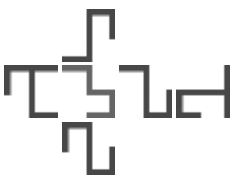

31 - 32 Moves

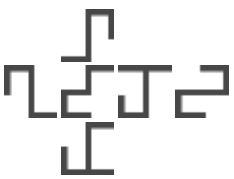

32 - 32 Moves

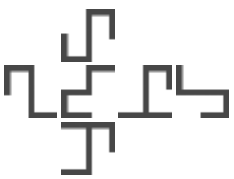

33 - 32 Moves

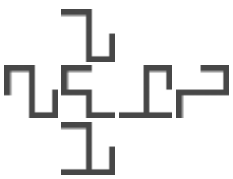

34 - 32 Moves

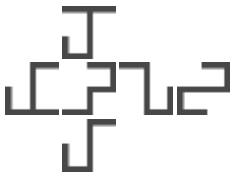

35 - 33 Moves

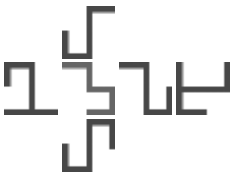

36 - 34 Moves


37 - 35 Moves


38 - 35 Moves


39 - 36 Moves


40 - 36 Moves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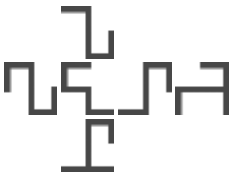
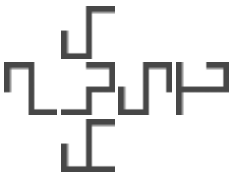
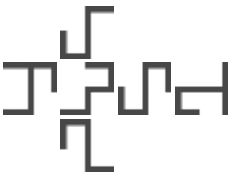

42 - 37 Moves


43 - 38 Moves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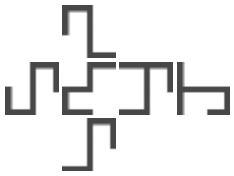
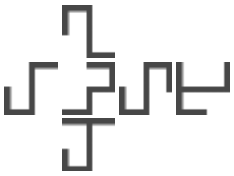
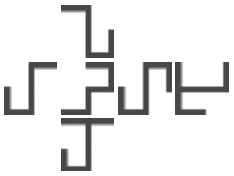

45 - 39 Moves


46 - 39 Moves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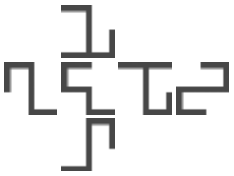
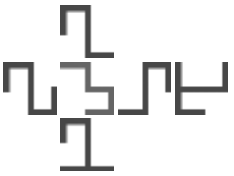

48 - 41 Moves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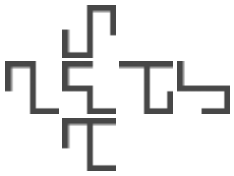
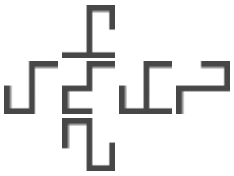

50 - 42 Moves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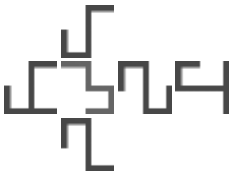
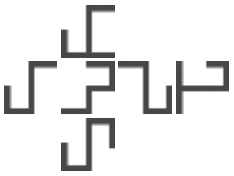

52 - 43 Moves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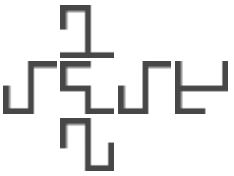
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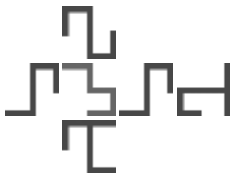
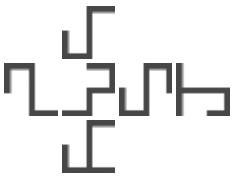
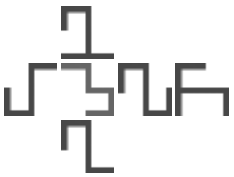

55 - 45 Moves


56 - 46 Moves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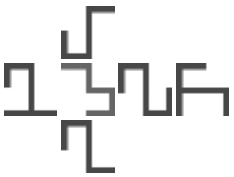
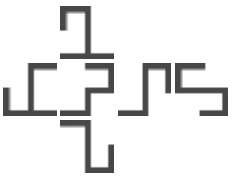
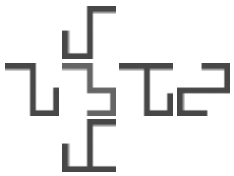

58 - 47 Moves


59 - 48 Moves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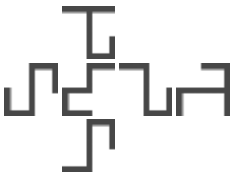
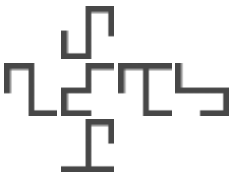
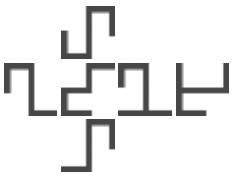
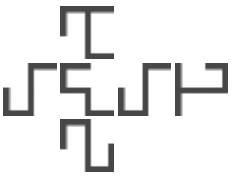
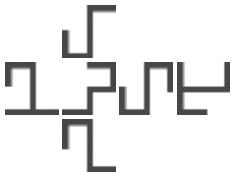
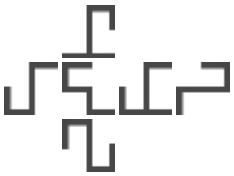

61 - 49 Moves

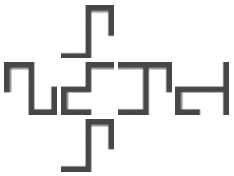

62 - 50 Moves

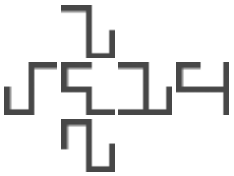

63 - 51 Moves

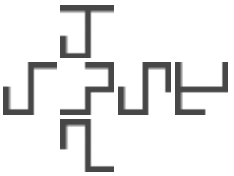

64 - 52 Moves

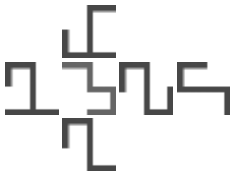

65 - 53 Moves

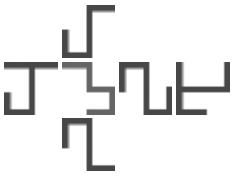

66 - 54 Moves

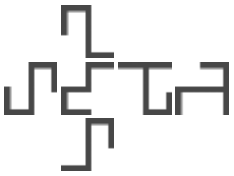

67 - 55 Moves

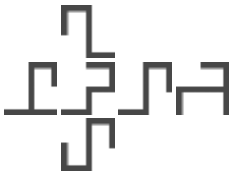

68 - 55 Moves

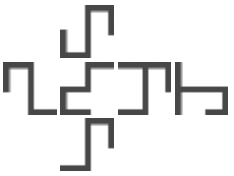

69 - 56 Moves

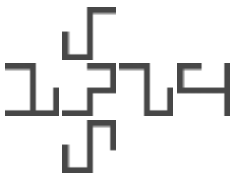

70 - 57 Moves

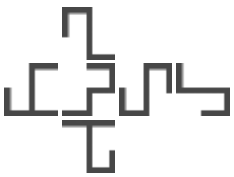

71 - 57 Moves

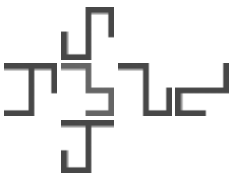

72 - 58 Moves

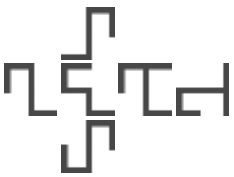

73 - 58 Moves

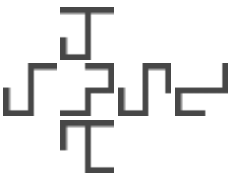

74 - 59 Moves

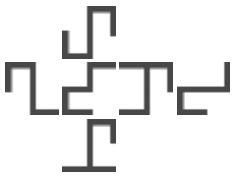

75 - 59 Moves

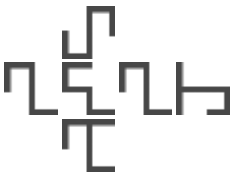

76 - 60 Moves

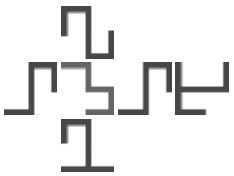

77 - 60 Moves

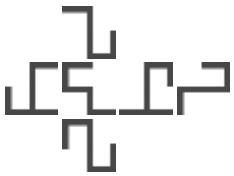

78 - 60 Moves

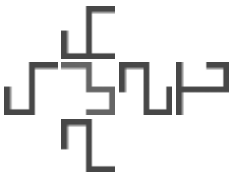

79 - 61 Moves

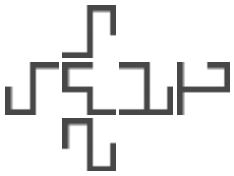

80 - 61 Moves

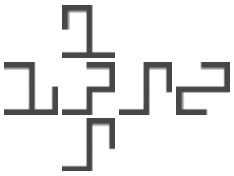

81 - 62 Moves

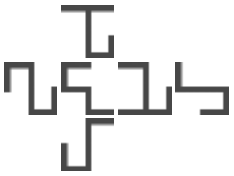

82 - 63 Moves

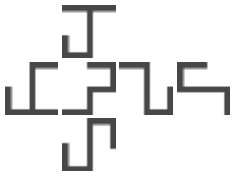

83 - 64 Moves

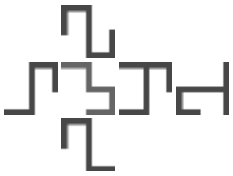

84 - 65 Moves

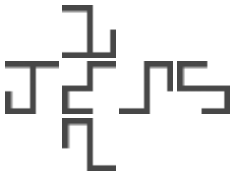

85 - 65 Moves

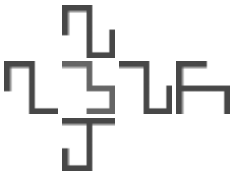

86 - 66 Moves

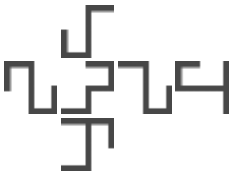

87 - 66 Moves

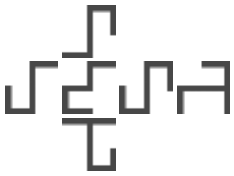

88 - 66 Moves

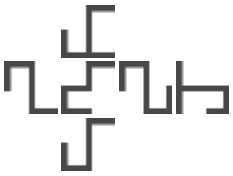

89 - 67 Moves

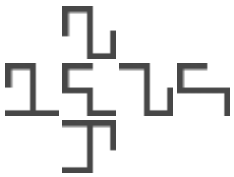

90 - 68 Moves

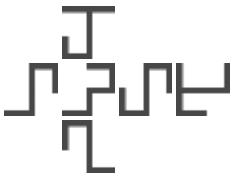

91 - 69 Moves

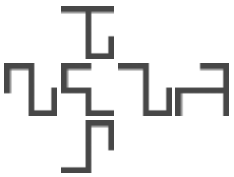

92 - 70 Moves

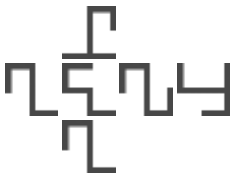

93 - 71 Moves

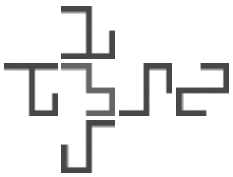

94 - 72 Moves

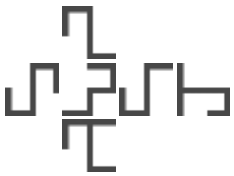

95 - 73 Moves

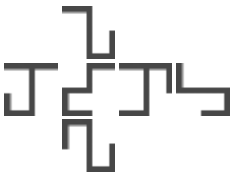

96 - 74 Moves

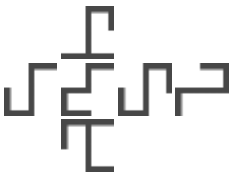

97 - 75 Moves

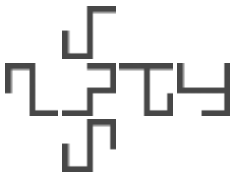

98 - 77 Moves

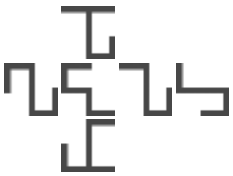

99 - 78 Moves

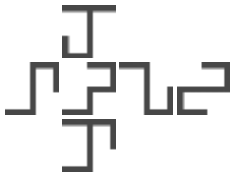

100 - 79 Moves

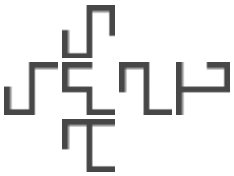

101 - 80 Moves

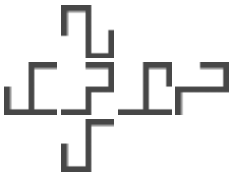

102 - 81 Moves

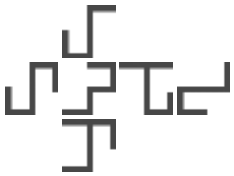

103 - 82 Moves

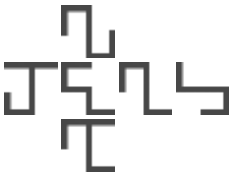

104 - 84 Moves

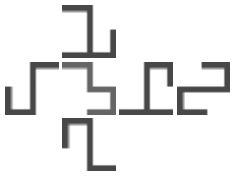

105 - 85 Moves

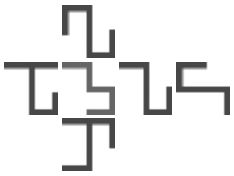

106 - 86 Moves

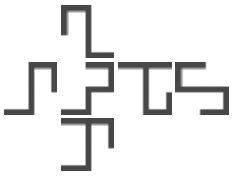

107 - 91 Moves


108 - 92 Moves


109 - 94 Moves


110 - 97 Moves


111 - 109 Moves


112 - 115 Moves