

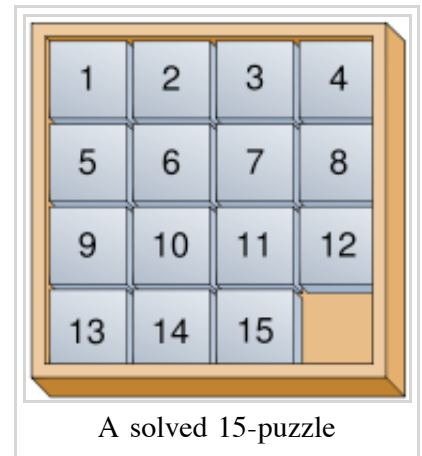
# Fifteen puzzle

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The *n*-puzzle is known in various versions, including the **8 puzzle**, the **15 puzzle**, and with various names. It is a sliding puzzle that consists of a grid of numbered squares with one square missing, and the labels on the squares jumbled up. If the grid is 3×3, the puzzle is called the 8-puzzle or 9-puzzle. If the grid is 4×4, the puzzle is called the 15-puzzle or 16-puzzle. The goal of the puzzle is to un-jumble the squares by only making moves which slide squares into the empty space, in turn revealing another empty space in the position of the moved piece.

The n-puzzle is a classical problem for modelling algorithms involving heuristics. Commonly used heuristics for this problem include counting the number of misplaced tiles and finding the sum of the Manhattan distances between each block and its position in the goal configuration. Note that both are *admissible*, i.e., they never overestimate the number of moves left, which ensures optimality for certain search algorithms such as A\*.

A simple parity argument shows that half of the starting positions for the *n*-puzzle are impossible to resolve, no matter how many moves are made. This is done by considering a function of the tile configuration that is invariant under any valid move, and then using this to partition the space of all possible labeled states into two equivalence classes of reachable and unreachable states (see example below).



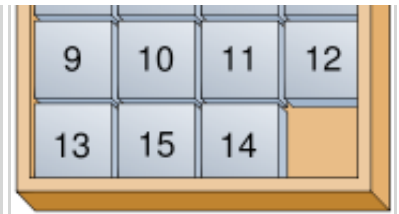
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## Noyes Chapman's Fifteen Puzzle



In its most famous version, the **Fifteen Puzzle**, initially known as the **Gem Puzzle**, **Boss Puzzle**, **Game of Fifteen**, **Mystic Square**, and many others, is a game in which 15 of the 16 squares of a 4×4 frame are filled with numbered sliding pieces, leaving one space in which to slide one piece at a time. The object is to slide the 15 pieces into numerical order with the empty



Noyes Chapman's unsolvable 15-puzzle, with tiles 14 and 15 exchanged

space after the 15 block. In the initial configuration, pieces 14 and 15 are exchanged.

## Solution

This puzzle is not solvable. The proof involves noting that there are two distinct sets of positions which can be assembled from the pieces with different parity, and there is no way of moving between them using the allowed moves, as they preserve parity. The parity in this context (the invariant) is the parity (odd or even) of the number of pairs of pieces in reverse order *plus* the row number of the empty square. For the order of the 15 pieces consider line 2 after line 1, etc., like words on a page.

Thus an even permutation of the order of the 15 pieces can only be obtained if the empty square is not moved or moved two rows, and an odd permutation of the order of the 15 pieces can only be obtained if the empty square is moved one or three rows.

By contrast, note that considering the parity of permutations of all 16 squares (15 pieces plus empty square) is not meaningful here, because it changes with every move.

## History

Sam Loyd claimed from 1891 until his death in 1911 that he invented the puzzle. But he had nothing to do with the invention or popularity of the puzzle. The puzzle was "invented" by Noyes Palmer Chapman, a postmaster in Canastota, New York, who is said to have shown friends, as early as 1874, a precursor puzzle consisting of 16 numbered blocks that were to be put together in rows of four, each summing to 34. Copies of the improved Fifteen Puzzle made their way to Syracuse, New York by way of Noyes' son, Frank, and from there, via sundry connections, to Watch Hill, RI, and finally to Hartford (Connecticut), where students in the American School for the Deaf started manufacturing the puzzle and, by December 1879, selling them both locally and in Boston (Massachusetts). Shown one of these, Matthias Rice, who ran a fancy woodworking business in Boston, started manufacturing the puzzle sometime in December 1879 and convinced a "Yankee Notions" fancy goods dealer to sell them under the name of "Gem Puzzle". In late-January 1880, Dr. Charles Pevey, a dentist in Worcester, Massachusetts, garnered some attention by offering a cash reward for a solution to the Fifteen Puzzle. The game became a craze in the U.S. in February 1880, Canada in March, Europe in April, but that craze had pretty much dissipated by July. Apparently the puzzle was not introduced to Japan until 1889. Noyes Chapman had applied for a patent on his "Block Solitaire Puzzle" on February 21, 1880. However, that patent was rejected, likely because it was not sufficiently different from the August 20, 1878 "Puzzle-Blocks" patent granted to Ernest U. Kinsey.<sup>[1]</sup>

For larger versions of the  $n$ -puzzle, finding a solution is easy, but the problem of finding the *shortest* solution is NP-hard.<sup>[2]</sup>

In the USSR the Minus Cube was manufactured, a 3D variant of the 15-puzzle.

Bobby Fischer is an expert at solving the 15-Puzzle, provided that it is in a configuration that can be solved,

and he has been timed to be able to solve it every time within 25 seconds. Fischer demonstrated this on November 8, 1972 on *The Tonight Show Starring Johnny Carson*.

## See also

- Rubik's Cube
- Minus Cube

## References

- <sup>^</sup> *The 15 Puzzle*, by Jerry Slocum & Dic Sonneveld. ISBN 1-890980-15-3
- <sup>^</sup> Daniel Ratner, Manfred K. Warmuth. *Finding a Shortest Solution for the  $N \times N$  Extension of the 15-PUZZLE Is Intractable*. National Conference on Artificial Intelligence, 1986.

## External links

- Sliding Grid Puzzles (<http://funmin.com/online-games/n-puzzle/index.php>) : Free online 8-puzzle, 15-puzzle games developed using javascript.
- Fifteen Puzzle (<http://fifteen.logical-games.org>) : A free flash version by logical-games.org. Daily Puzzles.
- Sliding Grid Puzzle (<http://tomazos.com/puzzle>) : A simple demonstation of XHTML, CSS, Javascript and PHP implementing a rudimentary version of the Sliding Grid Puzzle by Andrew Tomazos. Generates solvable puzzles as well as unsolvable ones.
- Matt's Puzzle (<http://www.mattspuzzle.co.uk>) : A popular free Fifteen Puzzle game with video support by Matt Briggs.
- 8-Puzzles-Applet (<http://www.stefan-baur.de/cs.web.mashup.8puzzles.html>) : A Java-Applet as mashup for all web-users, implemented by Stefan Baur.

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