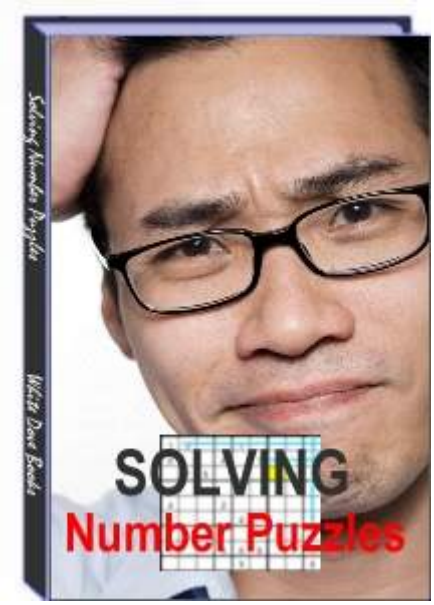
Solving Number Puzzles



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Contents

The Origins of The Number Puzzle

The Number Puzzle has exploded into the popular consciousness of Western culture in the last few years. It has gone from an obscure Japanese game to a mass addiction. Virtually every newspaper and magazine carries a Number Puzzle these days and the bookshelves are positively littered with Number Puzzle books. If you are a serious addict, you can even buy programs for your computer to create a seemingly infinite number of Number Puzzles.

Though how many people know where this fiendishly addictive game came from? Some, I am sure, believe it originated in the warped mind of a newspaper puzzle creator, but its actual origins are much older.

The Number Puzzle was born in the 18th century in Japan, though some say it was China. It is a logic based puzzle known in the USA as Number Place, which translates as Nanpure in Japanese.

The word Sudoku ™ – a contraction of a longer phrase “suuji wa dokushin ni kagiru” (数字は独身に限る) which means “the digits must remain single” - is actually trademarked by the puzzle publisher Nikoli Ltd in Japan. Hence the references to the

puzzle as *Number Place* by some publishers. In this publication, we refer to the puzzle as the Number Puzzle to avoid any possible trademark infringement.

The Number Puzzle itself draws upon the theory of magic squares, which were held in high regard by earlier cultures such as the ancient Greeks, Chinese and Babylonians. A magic square is very similar in appearance to a Number Puzzle square in that it is a square of numbers, but each column, row and diagonal adds up to the same number. However, these squares were used for magical, divinatory, and astrological purposes rather than entertainment.

The first known magic square dates back to 2800 B.C. in China where Fuh-Hi, the mythical founder of Chinese civilization invented a magic square called the “Loh-Shu” or scroll of the river Loh. Other cultures also created magic squares to honour their gods and to divine their futures.

Magic squares remained very much the property of the mystics and alchemists for a very long time. In the sixteenth century, Cornelius Agrippa, a renowned German physician and theologian constructed seven magic squares. These were associated with the seven planets then known to science, which included the Sun and the Moon.

Then in 1979, The Number Puzzle was first published in the USA in a logic and puzzle book. It was slow to grip the imagination of Western cultures, occasionally appearing in magazines for a bit of variety. Then it caught on in Japan in the mid 1980's, before finally sweeping through other Western cultures with all the unstoppability of a barbarian horde in 2005. The Times published the first The Number Puzzle in the UK on 12th November 2004, calling it 'Su Doko'. From then on, The Number Puzzle's future was secured.

The Number Puzzle made its first appearance on a home computer in the form of DigitHunt on the Commodore 64 in 1989, and has appeared in various forms since. Today though, you can find many different versions for your computer, all promising to feed your addiction and stretch your mind.

What is it that makes The Number Puzzle so fiendishly attractive to people?

The rules for The Number Puzzle are astonishingly simple compared to some puzzles, but the line of reasoning required to complete a puzzle can be extremely complex. This combination of simplicity and complexity makes it very addictive as you don't feel put off by a complex set of rules. You can learn to play The Number Puzzle in minutes, but spend hours trying to

solve a puzzle. The rules are very simple, each column and row must contain only one instance of each number. The practicality of solving the puzzle keeps many a commuter occupied on their journey to work.

The first World Puzzle Championship took place in 2006, in Lucca, Italy on March 10th to March 12th. Who knows, with what you are going to learn in this little book, perhaps you could become a master and look forward to competing in future championships.

Playing The Puzzle

Number Puzzles come in a variety of shapes. Most frequently the puzzles come in a 9 by 9 grid, which is made up of three 3 x 3 sub grids called regions. These regions are also known as boxes, blocks, quadrants and other terms.

Some cells already contain numbers called givens or clues. Your goal, as the player, is to fill in the empty cells. Each cell must contain only one number so that each column, row and region contains the numbers 1-9 just once. This is where the "single number" from the puzzle's name comes from.

The difficulty of the puzzles can vary wildly, and the number of givens provided has no reflection on the difficulty of the puzzle. A puzzle with very few givens can be very easy, just as a puzzle with lots of givens can be difficult. The difficulty of the game depends on the positioning and relevance of the numbers.

Of course, you are not just limited to a 9 by 9 grid with Number Puzzles. 4 by 4 grids with 2 x 2 regions have been used, as have a 6 by 6 grid with 2 x 3 regions. The Times publishes a massive 12 by 12 grid with twelve 4x 3 regions.

If you are seriously addicted then you can find even bigger puzzles to challenge your mind. 16 by 16 grids have been published, using 1 through to G. If that's not enough of a challenge for you then there is a 25 by 25 grid available to feed your addiction.

Of course, being such a popular puzzle, there are now many variants with every newspaper and publisher trying to out do each to gain readers, popularity and sales. Some variants require that each region, column or row add up to a certain total. Even three dimensional puzzles have appeared to seriously challenge the addicted.

Variants with letters instead of numbers have also appeared, though these are functionally no different from the numerical puzzles unless the letters spell something. Some variants have the diagonals spell words, whereas the Code Duko by Steve Schaefer embeds an entire sentence into the grid.

Whatever bookshop or magazine stand you frequent you will find book after book offering you everything from simple puzzles to the more fiendishly difficult ones. The opportunity to feed your addiction has never been so good.

Simple Tactics

If you have been living in a cave on top of a mountain for the last two years you may have missed The Number Puzzle craze that is sweeping Western culture.

So you've come out of your cave and found this strange grid of numbers in a newspaper. What on earth do you do with it?

The rules for The Number Puzzle are very simple. Each row, column and region must contain only one instance of each number. The solving of a Number Puzzle can be much more complex.

Through a process of elimination, deduction and logic you have to work out which numbers go into each cell.

1	6	2	?	3	9	7	4	5
	5							
		9	4					
8					5			8
		3		6		1	2	
					7			
2			7		8			9
	7					3		
		4		1				2

In the above example, what number would go into the cell with the question mark in?

Bearing in mind the rules, you can only have one instance of each number in each column, row, or region, there is only one number that will fit – 8.

1	6	2	8	3	9	7	4	5
	5							
	?	9	4					
8					5			8
		3		6		1	2	
					7			
2			7		8			9
	7					3		
		4		1				2

Now you decide you are going to concentrate on the cell with the question mark in above.

You know that because there's only one instance of each number allowed per region. Therefore this cell cannot contain the numbers 1, 6, 2, 5 or 9.

You also know that only one instance of each number is allowed per row and column. Therefore this cell cannot be 4 or 7 either.

So by some deduction you know this cell cannot contain the numbers 1, 2, 4, 5, 6, 7, 9, which means it can only contain 3 or 8. You can write these into your grid in superscript form as shown below.

1	6	2	8	3	9	7	4	5
	5							
	3 8	9	4					
8					5			8
		3		6		1	2	
					7			
2			7		8			9
	7					3		
		4		1				2

You can also deduce from this region where the number 4 belongs. As you know that each row and column can only contain one instance of each number there is only one place 4 can go:

1	6	2	8	3	9	7	4	5
4	5							
	3 8	9	4					
8					5			8
		3		6		1	2	
					7			
2			7		8			9
	7					3		
		4		1				2

You can also deduce from this region where the rest of the numbers go:

1	6	2	8	3	9	7	4	5
4	5	7 8						
7 3	3 8	9	4					
8					5			8
		3		6		1	2	
					7			
2			7		8			9
	7					3		
		4		1				2

Using these simple techniques, you can deduce which numbers must be in which column. With these two options, you can now set you sights on another region and complete the puzzle.

And when you are done, instead of retreating back to your cave you can feed your new Number Puzzle addiction with any number of books, newspapers or computer programs.

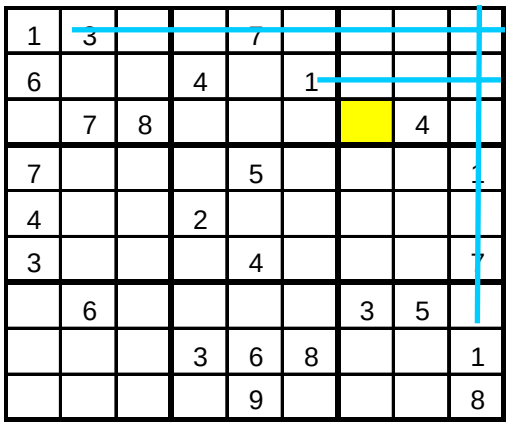
Solving Number Puzzles – Part 1

There are three main ways of solving the fiendishly difficult puzzle. In this chapter, you will learn about the scanning method.

When you start a puzzle, you scan it, and then you continue to scan the puzzle periodically throughout the solution. There are two basic techniques when it comes to scanning.

Firstly, there is the method known as Cross Hatching. This is where you can the rows (or columns) to determine which line in a region contains a certain number, by a process of elimination. This is then repeated with each column and row. If you scan each number in order of their frequency then you can solve the puzzle quicker. You must be systematic with this process, checking each number from 1 to 9.

The grid below illustrates the process of cross hatching



In this example, you know that the region in the top right much contain the number 1. By hatching up from the ones elsewhere in the grid, you can determine exactly where this number must be located. As you can see from the blue lines above, two rows and one column are immediately eliminated as they already contain the number 1. Therefore there is only one location left which could possibly contain this number, shown by the yellow square above.

The second method involves counting the numbers 1 to 9 in each region, rows and column to identify the missing numbers. Counting based on the last discovered numbers may well speed up the search. In tougher puzzles the easiest way to determine the value of a single cell is by counting in reverse. That means scanning the cell's region, row and column for values that cell cannot be. Through this, you see what numbers are left.

Once you are more experienced with the puzzle you may start to use what is known as “contingencies” whilst you are scanning. This is where you narrow the possible location of a number to two or three cells within a region, row or column. These possibilities can then be used to help you eliminate other cells as you continue with the cross hatching and counting.

If the puzzle is particularly fiendish, then you may have to use multiple contingencies which will mean keeping your pencil eraser handy as your brain does somersaults to keep them all in their right place.

If a puzzle can be solved solely by scanning, without having to identify contingencies, then it is classified as an “easy” puzzle. More difficult puzzles are those that cannot be solved by this method alone and will need the other methods described in the next two articles in this series.

Solving Number Puzzles – Part 2

When no further numbers can be found, scanning stops being useful. It is then time to use a different technique and engage in some logical analysis. This type of analysis is called marking, and involves physically making marks on the puzzle to help you keep track of your analysis.

The next step to solving your puzzle is to mark possible numbers in the blank cells. There are two popular methods for this, subscripts and dots.

Using the subscript notation format means basically writing the digits in small letters in the cells. Most newspaper puzzles though are too small to accommodate more than a few numbers written in.

The second technique is using a pattern of dots, where a dot in the top left hand corner represents a one and a dot in the bottom right corner represents a nine.

You need to be careful though as it is easy to inadvertently place other marks which look like dots in the cells. This is shown in the table below.

1				3		7		5
	5							
		9	4					
8					5			8
		3		6		1	2	
					7			
2			7		8			9
	7					3		
		4		1				2

The code for the dots is shown in the following table:

1	2	3
4	5	6
7	8	9

Another alternative method is to fill a cell with Numbers that it cannot be. This way, a cell starts empty and as you become more and more aware of what the cell cannot be, the cell fills up. Finally, you will have just one number missing and that has to be the value of the cell.

Marking will help you to keep track of your logical analysis. Start using marking on the simpler puzzles so that you can get used to how it works. Then as you progress to the more complex and larger puzzles you will find them much easier to solve.

Solving The Number Puzzle – Part 3

There are many more techniques that you can use to solve that Number Puzzle. As The Number Puzzle craze has gripped society, so many different methods of solving these fiendish puzzles have appeared.

A popular one is known as pairing.

1	6 4	2	8	3 6	9	7	6 4	5

In the above example two squares have the same candidate lists – 6 and 4. This means that these two cells use those two numbers between them. Therefore the third cell, contain 3 and 6 cannot actually contain the number 6. It has to be 3.

This technique can also be called Naked Pairing, and the same concept can be expanded into what is called a Triple.

1	6 8 4	2	6 3	6 8 4	9	7	6 8 4	5

In this example, you can see that there are three columns that contain the numbers 6, 8 and 4. This means that the fourth column cannot contain the number 6.

This pairing theory can be expanded to what is called Hidden Pairs, illustrated in the region below:

7	23	235
1259	8	4
159	6	35

A hidden pair is where two numbers match, but are hidden because they are in a cell with other numbers. In the above example you can see a hidden pair with Numbers 1 and 5. This example also contains a second hidden pair, can you spot it?

Of course, you can also get hidden triples and even hidden quads. However, hidden quads are much harder to spot and much rarer.

There are many more methods of solving a Number Puzzle depending on how advanced a puzzler you are.

There are techniques ranging from using colours to mark the cells to a technique called Swordfish where you are using knowledge from three rows to deduce numbers.

You can even use a technique called X-Wing, where there are two lines, each having the same two positions for a number.

You can further develop your Number Puzzle skills and learn a technique called Nishio, which is one step removed from pure guesswork. In this technique you find some cells with just a couple of candidate numbers. You then pick on of these numbers, almost at random, to work with.

You then work through the puzzle using this number. If it is right, then great you have solved the puzzle. If it is wrong then you need to back track your work and select the other number. It's at this time that you are grateful you chose to use a pencil!

If your Number Puzzle gets too much for you then the final solution would be a computer solving problem. There are many on the market to help you. Some are free and some will cost you money. If you do a Google for "The Sudoku Solver" then you will find any number of possibilities to help you sleep at night and resolve that puzzle.

When All Else Fails

You have been working on that fiendishly difficult Number Puzzle now for days and are no closer to solving it. So what do you do?

Well, there is an advanced strategy that you can use to solve your puzzle. It's complex, tricky, and doesn't always work. It's called guessing. And any good Number Puzzle guesser must arm themselves with a pencil and eraser.

Most Number Puzzles won't require you to make any guesses, but sometimes it may appear to be the easiest way forwards. Often your guesses won't really be guesses but logical leaps of faith. You may well be guessing because you are getting frustrated, you are keen to solve it or because you are just plain stuck.

If it comes down to guessing, then try to make a guess in a cell where your options are limited. This gives you more of a chance of making sure the guess is right and then it will open up a whole set of new cells.

Of course, guessing isn't an instant panacea for solving your Number Puzzle problems. When you have guessed the contents

of one cell there are plenty more still to complete. The guess may be correct, it may not, but I doesn't instantly mean your work is over.

And the worst part?

One guess may not be enough. If you are stuck and out of ideas then you may find that you have to make a number of guesses in order to complete the puzzle. Each guess you make can lead you down a different path where you make difference choices. It's probably best to keep that eraser handy so you can back track if required.

If you want to impress your friends, then tell them you are practicing bifurcation.

They will be very impressed and nod sagely not wishing to give away the fact that they have no idea what bifurcation means. You can, of course, feel smug in the knowledge that you know it means guessing or trial and error.

If all else fails and you can't take it any more, then there is always one more last resort – computers. If you are truly stuck then there are Number Puzzle solvers online that you can download and run to solve that particularly tricky puzzle.

However, remember that this will take away much of your sense of fun and you will always feel that sense of satisfaction lacking.

A pencil, eraser, and your brain is by far the most satisfying that using a computer. When you've used brainpower to solve a Number Puzzle you have that satisfaction of knowing you did it. Whilst your friends are still struggling, you can lean back, feel smug and know you're smarter than them.

The Magic Square

Number Puzzles are derived from the more ancient Magic Square. These have been used for divination for aeons; the first known magic square was discovered in China and dates from 2800 B.C.

Magic squares have been the premise of magicians and alchemists for years, but they have also been a toy of recreational mathematics; something many school children have been introduced to.

In a magic square, each column, row, and diagonal adds up to the same number.

2	7	6
9	5	1
4	3	8

In the above example every row, column and diagonal adds up to 15.

The Lo shu scroll dating to 2800 B.C. is a magic square of this order, three by three with each row, column and diagonal adding up to 15. Interestingly, this is also the number of days in each of the 24 cycles of the Chinese solar day.

A four by four magic square was found in Khajuraho, India dating to the eleventh or twelfth century. This was a "panmagic" square, illustrated below.

3	10	15	6
13	8	1	12
2	11	14	7
16	5	4	9

In this example, the magic number is 34. As it is a panmagic square, the broken diagonals also sum correctly, e.g. 10 + 1 + 7 + 16 = 34, and 10 + 13 + 7 + 4 =34.

The magic square first appeared in European art courtesy of Albrecht Durer's engraving Melancholia I. This square was particularly interesting because not only is the number 34 is found in each column, row and diagonal, but it is also found in each of the quadrants, the centre four squares, the corner squares, the four outer numbers clockwise from the courses (3 + 8 + 14 + 9), and also the four counter clockwise. It also appears in a number of other places throughout the square.

Spend a few moments admiring Albrecht's square below and see how many more combinations you can find that add up to 34. Also, the two numbers in the middle of the bottom row give the date of the engraving, 1514.

16	3	2	13
5	10	11	8
9	6	7	12
4	15	14	1

Magic squares have even appeared in religious art. Similar to the Melancholia magic square, the magic sum of this square is 33, the age of Jesus at the time of the Passion. This magic square can be found in the Passion façade of the Sagrada Familia church in Barcelona and was designed by sculptor Joseph Subirachs.

1	14	14	4
11	7	6	9
8	10	10	5
13	2	3	15

As you can see from this example, magic squares do not have the same restriction a Number Puzzle has. A magic square can contain more than one instance of a number in a row or column. Unlike The Number Puzzle, magic squares do not always have regions that add up to a sum, but they can do.

Magic squares can be fun to play with. They can stretch your mind and make you think, much like The Number Puzzle. When you are ready to move on from The Number Puzzle, start designing magic squares. By the way, you can go bigger than four by four on a magic square …

The Number Puzzle in the Media

The Number Puzzle first appeared as a game in the 18th century. It took almost 200 years before it made it into the media.

In 1979 the first Number Puzzle was published in an American puzzle magazine called Dell Pencil Puzzles and Word Games where it was called “Number Place”.

Then it disappeared back into obscurity in the West, occasionally appearing in puzzle magazines. In 1984 the Monthly Nikolist paper in Japan published the same kind of puzzle under the name ‘Sudoku ’. Other magazines picked up on this puzzle fad, but due to copyright reasons couldn’t call it Sudoku ™.

It was in 1989 that The Number Puzzle made its first migration to computers. DigitHunt was published on the Commodore 64, bringing The Number Puzzle to a whole new audience. In 1995 it appeared on the Apple Macintosh, and then in 1996 on the Palm PDA.

In 1997 Wayne Gould, a retired judge from Hong Kong saw a partly completed puzzle in a Japanese bookshop. He spent the

next six year producing a computer program to quickly produce these puzzles.

Wayne knew that the British loved crosswords and puzzles, so he contacted The Times newspaper in London. As he imaged, they leapt upon the idea and on 12th November 2004 published it under the name of ‘Sudoku ’. Every issue of The Times since this date has contained a Number Puzzle.

The Number Puzzle immediately grabbed the attention of the public, and just three days later The Daily Mail published the puzzle, but called it “Codenumber”. On January 19th 2005 The Daily Telegraph published its puzzle, which was quickly picked up by other newspapers.

On May 20th 2005, The Number Puzzle made an intercontinental leap and appeared in The Daily Telegraph of Sydney. This massive surge of interest has resulted in The Number Puzzle being called “The fastest growing puzzle in the world”.

Despite being the first publishers of ‘Sudoku ’, The Times were caught napping by the Daily Telegraph. Whereas The Times hid the puzzle in the middle of the paper, The Telegraph splashed The Number Puzzle over the front page, realising that it was increasing sales. They took advantage of their market lead and

published the first book before the other papers realised just how popular the puzzle was.

By mid 2005, every paper in Britain contained a Number Puzzle and there was no escaping. Even small local papers were getting in on the popularity of the puzzle. The newspapers began to compete with each other, with both The Times and Daily Mail both claiming to be the first to feature this puzzle.

2005 was really the year that the Number Puzzle captured the imagination of the British people. The newspapers published more and more puzzles, even Teletext got in on the act. And then finally in July 2005, the satellite channel Sky One hosted the world's first live TV Sudoku show.

It was during the promotion of this show that Sky One built a 275 foot (84m) square puzzle on a hillside near Chipping Sodbury near Bristol, England. It was next to the M4 motorway and was coincided with a major road expansion which meant drivers were going slower and could safely view the puzzle. Unfortunately for the television show makers, the puzzle had 1,905 correct solutions, not the usual one solution.

The Number Puzzle, has captured the minds of tens of thousands of people. It’s a puzzle that is here to stay, but be warned, once you pick it up, you may struggle to put it down again.

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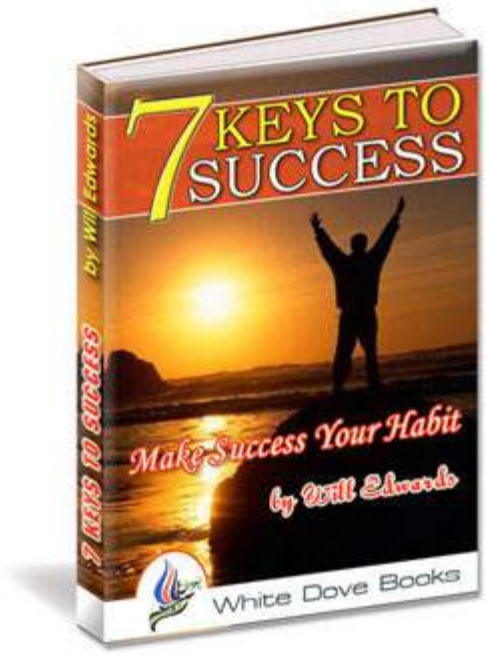

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Within its first three years, White Dove Books was recognised as one of the internet's leading sites for self help and personal development; breaking into the top 100,000 sites on the internet at the end of 2005.

The INSPIRATION newsletter was started in 2005 as a way of providing helpful information including tips, articles and free inspirational eBooks to our visitors.

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