

# Jaap's Puzzle Page

## Saturn (LD Games)



The Saturn puzzle consists of a ring, and on both sides there is a circular track with 16 discs that can slide along it. The 32 discs have colours painted on both sides. There is a bar across the middle of the ring, and the discs can slide onto this bar from one end. The bar can rotate (around its long axis) allowing the pieces to swap sides, and it also allows a piece to be replaced on the same side but flipped over. The aim is to arrange the pieces so that each side shows only four colours, four pieces of each colour.

It was made by LD Games in Belgium around 1994. It was invented by Ludo Arthur Marie Jules DeBergh, and patented 21 March 1996, [WO 96/08296](http://www.patent.govt.nz/patents/wo/96/08296).

There are 14 different colours used on the pieces. Once you know the 8 colours to use in the solution it becomes a fairly trivial puzzle, but it is hard to figure out the correct colours by simply playing with it.

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### The number of positions:

There are several different ways to measure this. There are 32 pieces which have 2 orientations, giving at most  $32! \times 2^{32}$  arrangements. This should be divided by about  $16^2$  if positions that differ only rotating the rings are considered to be the same. This gives  $32! \times 2^{24} = 4.41 \times 10^{42}$  positions. Note that this number is not at all an accurate reflection of its difficulty.

To solve this puzzle, the only difficulty is figuring out which 8 colours to use. Once that is known, it is quite easy to manipulate the puzzle to get that solution, because the following moves are possible:

1. Swap a piece on the front with one on the back of the puzzle (push both on the bar, rotate bar, push both pieces back onto the ring).
2. Reverse a piece (push it on the bar, rotate bar, push piece back onto the ring).
3. Move a piece from one part of the ring to the other (push it onto the bar, shift the ring and insert the piece at the correct spot).

All that remains therefore simply to work out the correct colour combination. There are 14 colours used. There are  $14!/8!6!=3003$  ways of choosing 8 of these.

### Solution:

The 14 colours are as follows:

	<b>Name</b>	<b>Colour # Times</b>
1.	Light Yellow	5
2.	Light Blue	5
3.	Dark Yellow	5
4.	Green	5
5.	Red	5
6.	Dark Red	5
7.	White	5
8.	Black	5
9.	Grey	4
10.	Pastel Green	4
11.	Dark Blue	4
12.	Pink	4
13.	Light Brown	4
14.	Dark Brown	4

The following table shows the colours used on all the pieces, in no particular order.

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

Each colour occurs at least 4 times, so no colour is immediately disqualified. There are however some scarce colours that occur exactly four times and some deductions can be made using them. For example, if two scarce colours are used on opposite sides of any piece of the puzzle (e.g. colours 9 and 12), then exactly one of those two colours is used in the solution, the other one is not.

The following argument determines which 8 colours to use.

1. Suppose colour 5 is used.
2. Then at least one of the colours 12 and 14 cannot be used (from pieces 5/12, 5/14)
3. Colour 9 must be used (from pieces 9/12, 9/14)
4. Neither 12 and 14 are used (from pieces 9/12, 9/14 and fact that 12 and 14 are scarce)
5. Colours 3,5,6,7,8 are used (from pieces x/12, x/14)
6. The remaining two colours to be chosen must be one of 1 or 2, and one of 4 or 10 (from pieces 1/2 and 4/10).
7. Colour 13 is not used (from pieces 3/4, 3/10, 3/13)
8. Colours 1 and 2 are both used (from pieces 13/1, 13/2)
9. This does not lead to a solution (we have 9 colours in use already) so the assumption that colour 5 is used is false.
10. Colour 5 is not used.
11. Colours 11, 12, 13, 14 are used (from pieces 5/11, 5/12, 5/13, 5/14)
12. Colours 2, 3, 5, 6, 7, 9 are not used (all occur twice opposite 11-14)
13. Colours 1, 4, 8, 10 are used (from 1/2, 2/4, 3/8, 2/10)
14. Solution colours are 1, 4, 8, 10, 11, 12, 13, 14.

	<b>Name</b>	<b>Colour</b>
1.	Light Yellow	
4.	Green	
8.	Black	
10.	Pastel Green	
11.	Dark Blue	
12.	Pink	
13.	Light Brown	
14.	Dark Brown	

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