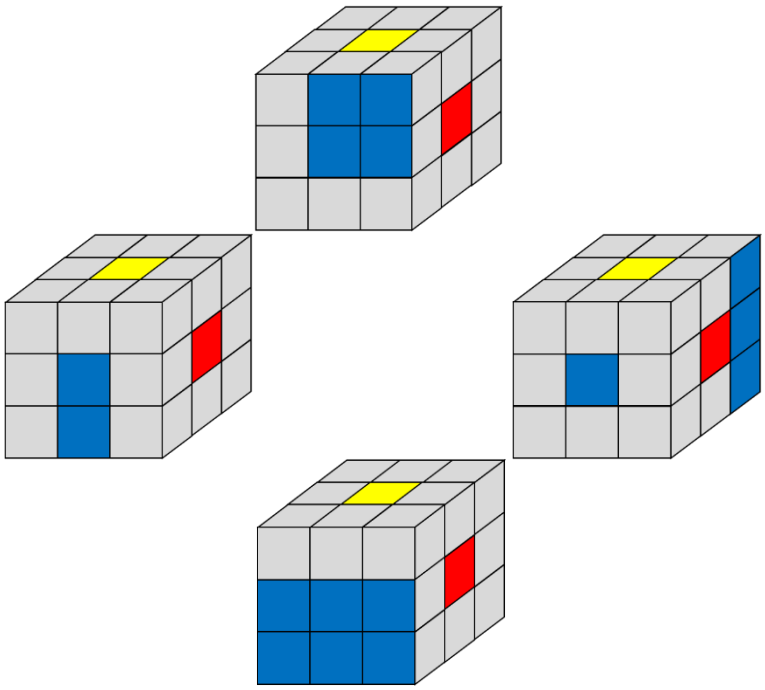

Rubik Cube

Pattern Variation

for Juliana

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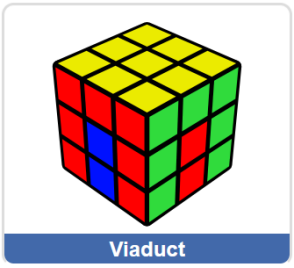
0 – Introduction

Rubik Cube is most probably the twisty puzzle with the highest number of players worldwide. Based on the number of Rubik Cube sold to the public the range of user/ player will be in the 500 million range. Numerous web sides are available for nearly every aspect of this game (see the literature/ bibliography – ref 1, 2 and 3).

Computer generated solver are available to solve every pattern as fast as possible with the minimum number of steps/ algorithm (God's number is obviously 20).

> By the way: the Cube has $8! \times 3^7 \times \frac{1}{2} \times 12! \times 2^{11} = 43.252.003.274.489.856.000$
>
> >>> app. 43×10^{18} possible positions – a really huge number

Speedcubing – solving an unknown cube in competition – is most famous. The record (as of 2018) is 3.47 second – unbelievable (see ref 4).



Source: www.ruwix.com/ pattern

Never the less sometimes you get interesting questions (in my case from my granddaughter).

> How many quadratic patterns are available on the Rubik Cube ?

I had a look to the world wide web and found nothing. Because of this I had to think about for myself and try to find the solutions for squares and rectangles.

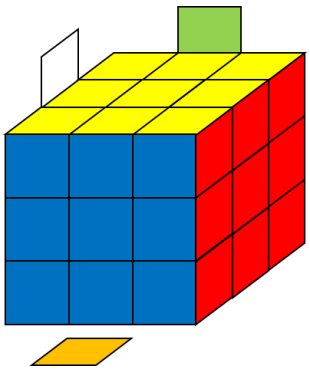
- 3 x 3 and 2 x 2 squares and
- 3 x 2 and 3 x 1 and 2 x 1 rectangles

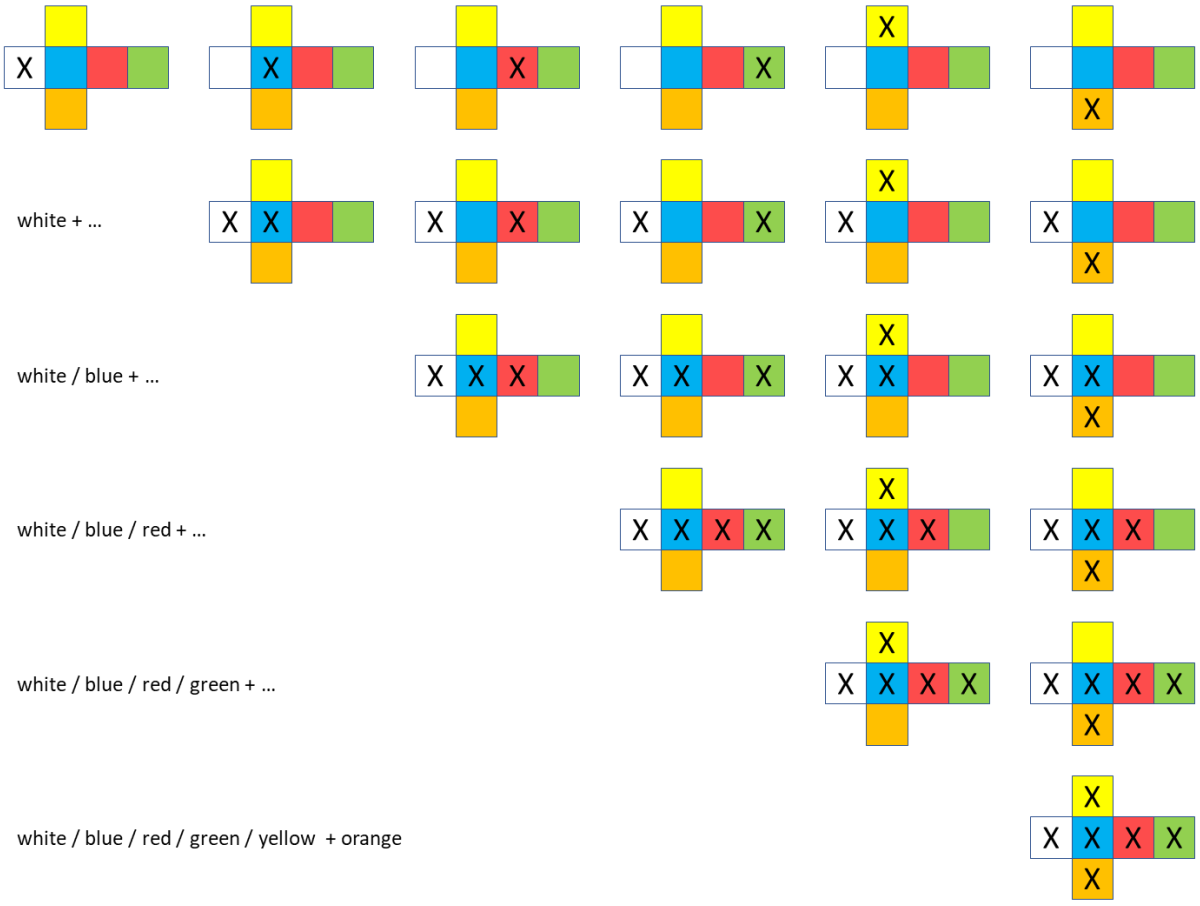
Enclosed you will find a short description about these patterns and the corresponding number of possible solutions (at least to my understanding). If you identify some errors please give me a hint via my contact data.

Have fun with this short overview!

1 – Nine – 3 x 3

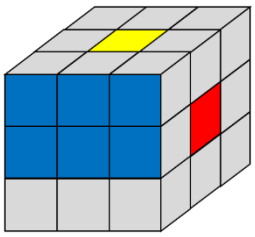
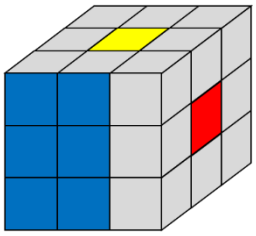
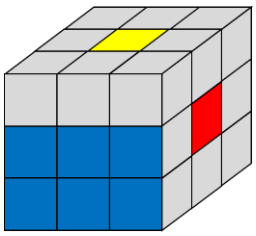
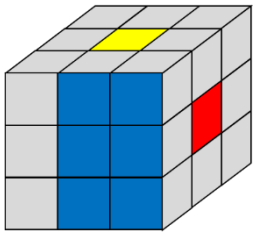
Front = blue
Right = red
Up = yellow
Left = white
Back = green
Bottom = orange





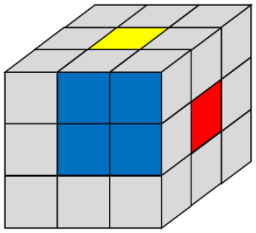
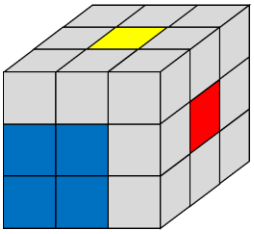
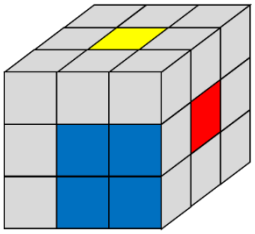
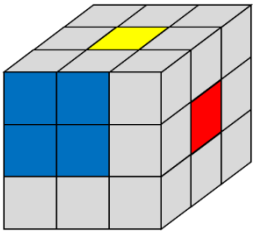
Only on central areas	For one colour on the central area – 6 possibilities	6
	For 2 colours you will get 5 combinations	5
	For 3 colours you will have 4	4
	For 4 colours you will have 3 combinations	3
	In total we will have 6 x 5 x 4 x 3	360 solutions

2 – Six – 3 x 2

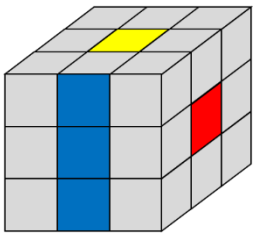
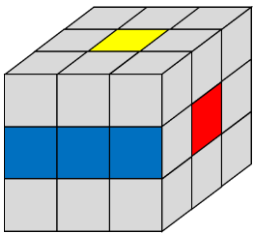
Only on central areas	For six colours on the central areas – 4 possibilities Therefore 4 x 6 = 24 single solutions	
	For 2 and more areas/ colours you will get 6x5x4x3x2x1 = 720 possible combinations	
	In total we will have 720 x 4	2880 solutions

3 – Four – 2 x 2

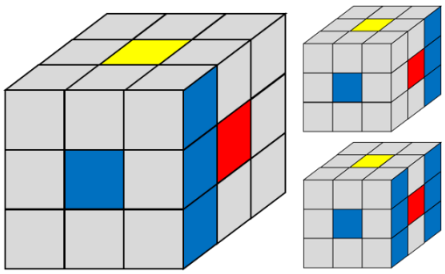
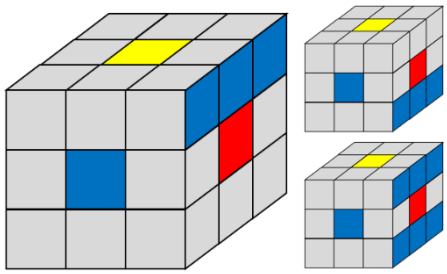
Only on central areas	For six colours on the central areas – 4 possibilities Therefore 4 x 6 = 24 single solutions	
	For 2 and more areas/ colours you will get 6x5x4x3x2x1 = 720 possible combinations	
	In total we will have 720 x 4	2880 solutions

4 – Three – 3 x 1 – Central line

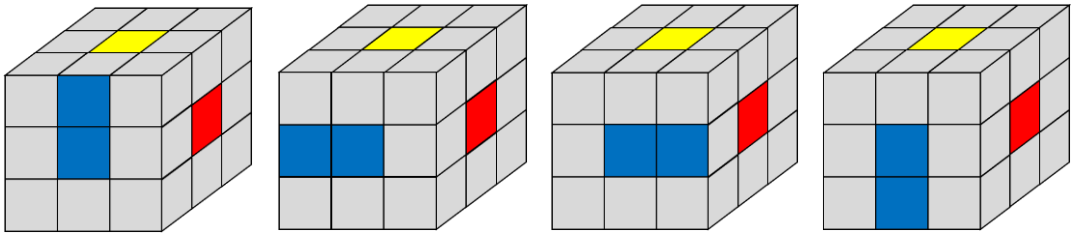
Only on central areas	For six colours on the central areas – 2 possibilities Therefore 2 x 6 = 12 single solutions	
	For 2 and more areas/ colours you will get 6x5x4x3x2x1 = 720 possible combinations	
	In total we will have 720 x 2	1440 solutions

5 – Three – 3 x 1 – Not on central areas

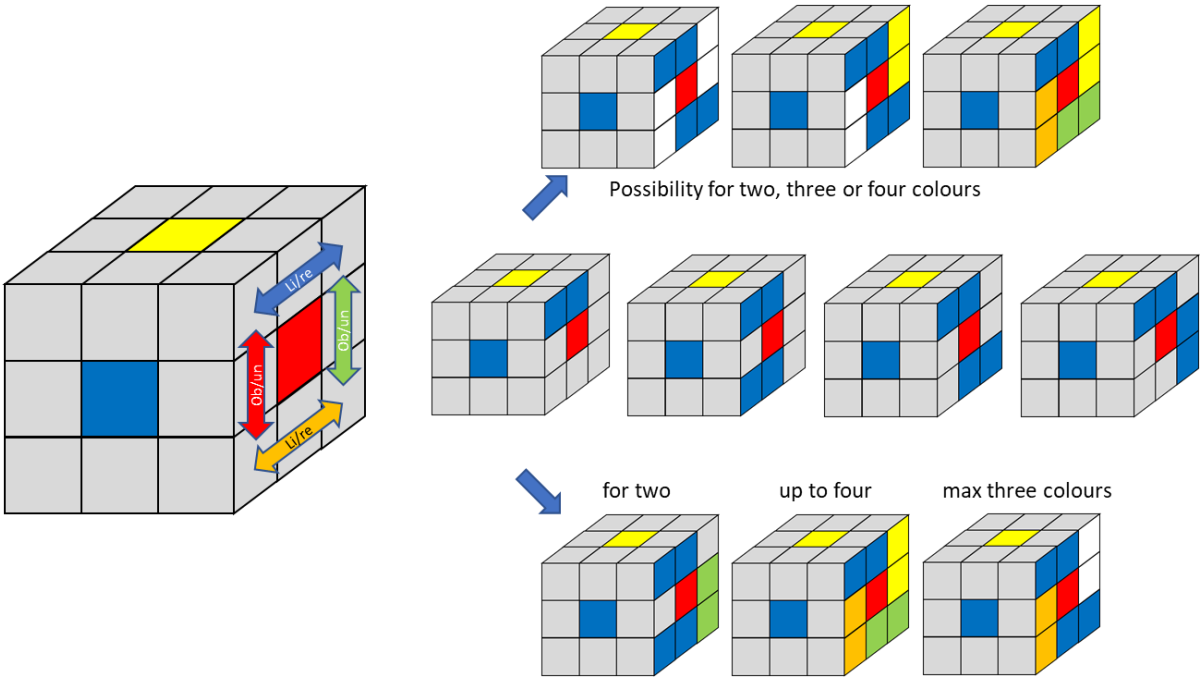
NOT on central areas	For five colours not on the central areas – we will have 6 possibilities. Therefore 5 x 6 = 30 single solutions	
	For single line and up to two areas/ colours you will get 5x4 = 20 possible combinations On all areas/ colours 5x4x3x2x1x = 120 For double line 5x4x3x2x1 = 120	
	In total we will have 120 x 20 + 120 x 2	2640 solutions

6 – Two – 2 x 1 – Central line



Only on central areas	For six colours on the central areas – 4 possibilities Therefore 4 x 6 = 24 single solutions	
	For 2 and more areas/ colours you will get 6x5x4x3x2x1 = 720 possible combinations	
	In total we will have 720 x 4	2880 solutions

7 – Two – 2 x 1 – Not on central areas



NOT on central areas	8 left/right or up/down times 4 pattern. Therefore 8 x 4 = 32 single pattern solutions	
	For a pair up to four areas/ colours you will get 5x4x3x2 = 120 possible combinations For double pair up to two areas 5x4 = 20 solution	
	In total we will have 120 x 8 + 20 x 3 x 8 =	1440 solutions

Bibliography/ References

No. #	Bibliography	Remarks
1	Finding the total number of legal permutations of the Rubik's Cubic. Trondheim: Trondheim Katedralskole, 2010 https://www.studocu.com/pt/document/universidade-de-lisboa/dissertacao-de-mestrado-em-engenharia-civil-e/finding-the-total-number-of-legal-permutations-of-the-rubiks-cube/19371113	Just 43 x 10^{18} solutions God's number is 20 - the minimum number of steps to solve every cube.
2	Ruwix Twisty Puzzle Wiki >>> https://ruwix.com/	Nearly everything about Rubik Cube
3	CubeSolve – How To Solve A Rubik's Cube https://cubesolve.com	Available in 18 languages, also in German
4	The current World Record is set by Yusheng Du (China), who solved the cube in 3.47 seconds see https://ruwix.com/blog/yusheng-du-record-347/	Speedcubing record in 2018
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