How to Solve a Rubik's Cube – A Beginner Tutorial

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Version 1

Introduction and Notes

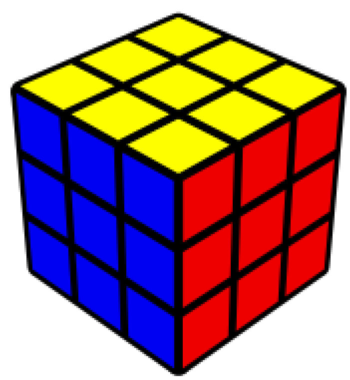
This set of instructions was created to standardize how we teach at workshops. However, it is designed so that it can also serve as a stand-alone document. Please direct any concerns to albertacubers@gmail.com.

The following is a version of a method known as *Layer-By-Layer (LBL)*, optimized for an easier transition into the *CFOP* speedsolving method. This method works by sequentially building three layers of the cube from bottom to top. Sequences of moves, called *algorithms*, are provided in this package, which provide a way to solve parts of the cube without destroying the progress made so far. This set of instructions assume you solve starting with white, but in principle, it is equivalent to start on any colour. Many images contain grey to emphasize the relevant pieces, but on a real cube, you will have to identify the relevant pieces yourself. The images in this document were generated in VisualCube.

There are three types of pieces on a standard 3x3x3 Rubik's cube:

- **Centre** pieces have a single colour, are located in the middle of each face, and never move.
- **Edge** pieces have two colours. There are 12 edge pieces in total.
- **Corner** pieces have three colours. There are 8 corner pieces in total.

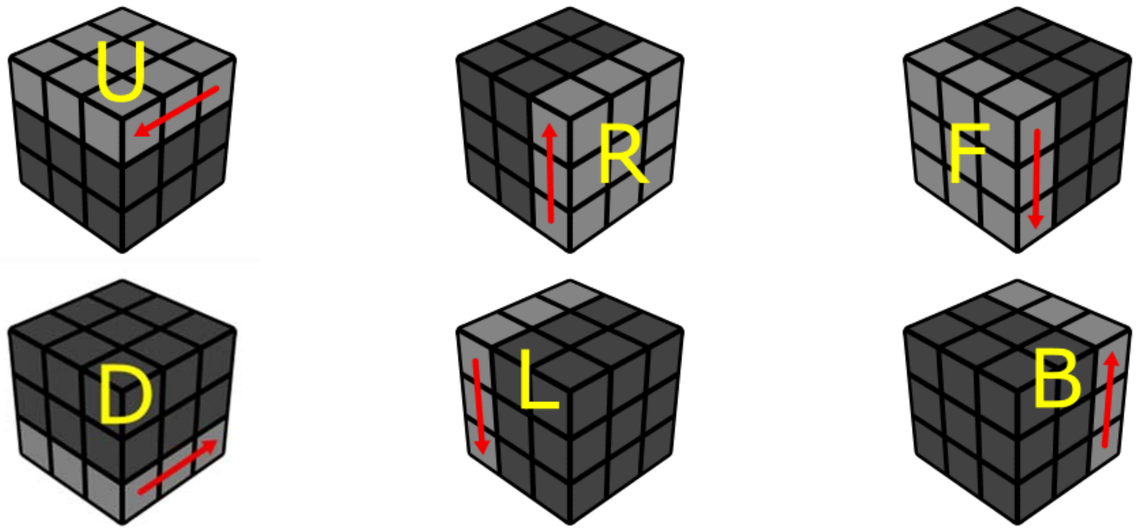
Since the centre pieces never move, they can be used as a reference to find out where each the other 20 pieces belong. For example, the blue-red edge piece belongs between the blue and red centers in a solved state. In this sense, a useful analogy is to think of the Rubik's cube as similar to a jigsaw puzzle where each of the twenty (non-centre) pieces need to be arranged around the centres.



Lastly, please do not peel the stickers off the puzzle, as this needlessly damages the stickers. To "cheat," turn a face 45° and remove an edge piece. The puzzle can then be reassembled in the correct configuration.

Notation

The six faces of a Rubik's cube are typically represented by a single letter describing its position; **U**p, **D**own, **L**eft, **R**ight, **F**ront, and **B**ack. By default, a single letter denotes a clockwise quarter turn (90°). A counterclockwise turn is denoted by a "prime" symbol (which looks like an apostrophe), and a half turn (180°) is denoted by the number 2.

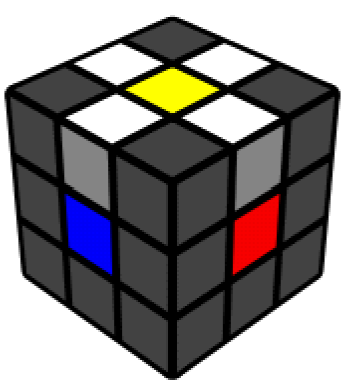


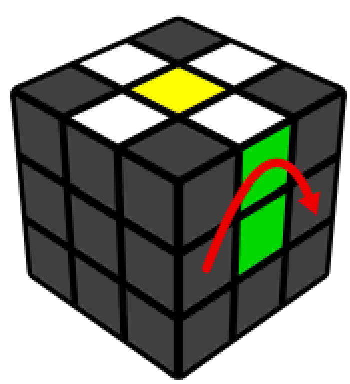
Step 0 (Optional): Daisy Cross

This is a preparatory step that helps to build the cross. It is significantly less efficient, but reduces the amount of thinking involved. We encourage you to try to solve it without this, but if you are having difficulties in forming the cross, this can be a useful strategy.

Start by placing your cross colour (white) on the bottom. Find the four edge pieces that contain white, and arrange them (in any order) around the yellow centre, ensuring that the white sides (of the edge pieces) face up.

Then, using only **U** moves, align the edge piece with its matching center on the side, and use a half turn to bring it to the bottom. Repeat until all four cross edges are in place.



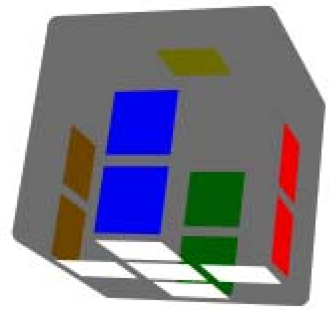


Step 1: Cross

Find the four pieces that contain white, and place them in their correct places, relative to the centres.

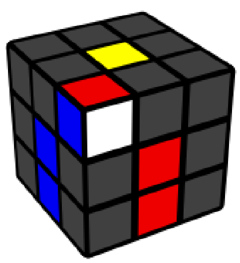
This may take some experimentation.

The final result should look like the diagram on the right.

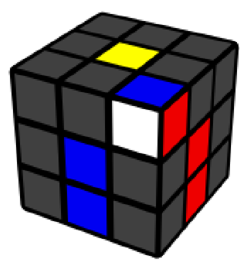


Step 2: Corners of First Layer

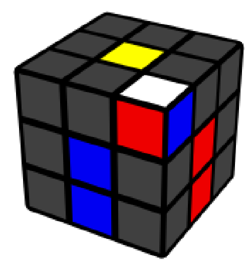
Identify a corner piece that contains white; it belongs in the first layer. Using **U** moves, place a corner above the spot where it belongs. It is helpful to start by solving the pieces where the white is not facing upward. Start with the white side of the corner facing **front**.



U' L' U L



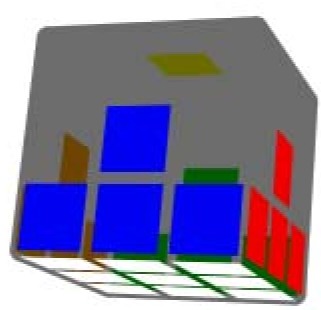
U R U' R'



Switch case using **R U2 R'**

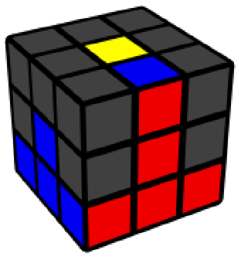
To deal with cases where white is on the top, place the corner over the spot where it belongs, and perform **R U2 R'** to reduce it to one of the above cases.

When all the corners are inserted, the first layer is complete.

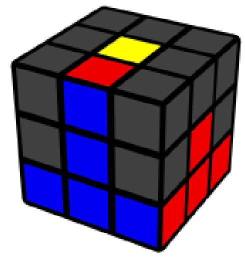


Step 3: Second Layer

Find a piece in the top layer that belongs in the middle layer. Using **U** moves, align it with the center, such that the colours match on the side. Determine whether the piece belongs in the spot to the left, or the spot to the right. It is possible to have configurations where there are no pieces in the top layer that belong in the middle layer, while the middle layer is still not solved. In this case, take a random piece in the top layer and use it (with the given algorithms) to move an incorrect middle layer piece back to the top layer, such that it can be re-inserted properly.

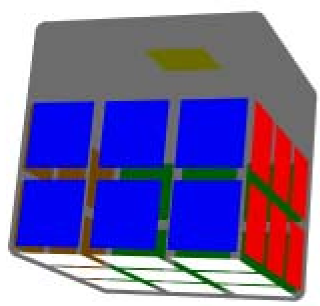


U' L' U L U F U' F'



U R U' R' U' F' U F

When all four second layer edges are in place, the first two layers are complete.



Notes: Last Layer

Unlike the first two layers, the last layer is primarily algorithmic in almost all beginner methods. All the algorithms in this section should preserve the first two layers when completed. Often, you will have to use an algorithm more than once to achieve the desired state. The general idea behind this last layer method is to ***orient*** all the last layer pieces (this step is collectively called *OLL*, or *Orientation of Last Layer*), and then ***permute*** those pieces while preserving their orientation (this step is collectively called *PLL*, or *Permutation of Last Layer*).

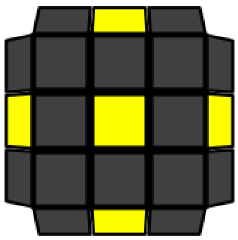
The following diagrams represent a top-down view of the cube. This means that the bottom pieces of the diagram (on the page) correspond to the front face (**F**) of the cube.

Terminology note: ***Orientation*** refers to how a piece is flipped, and ***permutation*** refers to the position the piece is in.

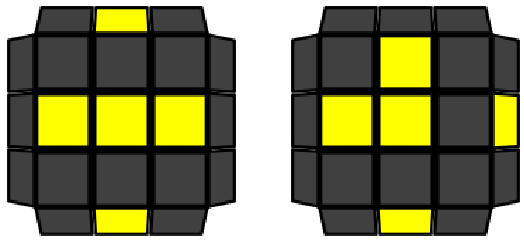
Step 4: Last Layer: Orient Edges

This step can be completed using the following algorithm. It may need to be performed more than once: pay attention to the orientation of the cube before you start this algorithm.

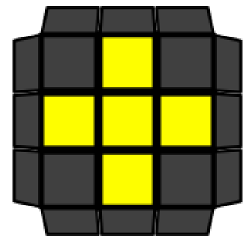
No edges oriented



Two edges oriented



All edges oriented



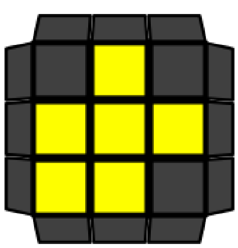
F R U R' U' F'

Step 5: Last Layer: Orient Corners

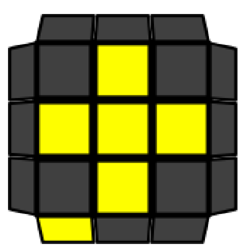
This step can be completed using the following algorithm. It may need to be performed more than once: pay attention to the orientation of the cube before you start this algorithm. During this step, pay attention to how many corners have yellow facing up.

R U R' U R U2 R'

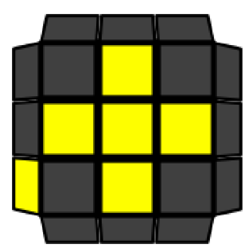
If one corner is yellow on the top, move it to the bottom left and perform the algorithm. (Sometimes, you will have to do this twice.)



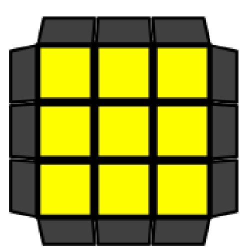
If two corners are yellow on the top, rotate the top layer until a yellow sticker is on the bottom left, facing front.



If no corners are yellow on the top, rotate the top layer until a yellow sticker is on the bottom left, facing left.

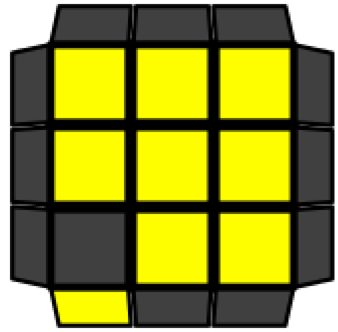


When this stage is complete, the entire top will be yellow.



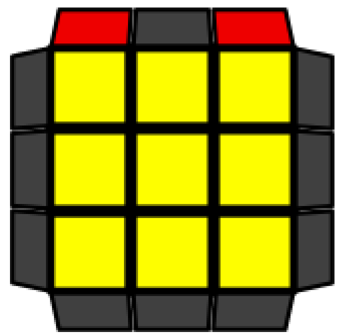
Note: Corner Twists

Using only "legal" (allowed) turns on the cube (U, D, R, L, F, B), it is impossible to reach a state with a single corner twisted. With modern speedcubes, it is possible to accidentally twist a corner, leaving the cube in an unsolvable state, which is referred to as a **corner twist**. In speedcubing scenarios, these are generally correlated with rough and inaccurate turning. If you find yourself with the following case, turn the face 45° and simply twist the corner back.



Step 6: Last Layer: Permute Corners

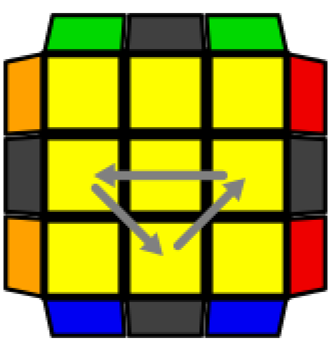
In this step, it is most helpful to look for "**headlights**," which are matching pairs of colours on the side of the last layer of the cube. If all four faces show headlights, the corners are considered solved (and can be put in place using only **U** moves). If there is one set of headlights, put it in the back face. If there are no headlights, performing the algorithm from anywhere will yield one set of "headlights.



R' F R' B2 R F' R' B2 R2

Step 7: Last Layer: Permute Edges

The following algorithms cycle three edges, preserving their orientation. It is not difficult to learn both, but performing one twice will solve the case for the other.



F2 U' L R' F2 L' R U' F2
Equivalently: **F2 U' M' U2 M U' F2**

F2 U L R' F2 L' R U F2
Equivalently: **F2 U M' U2 M U F2**

Notation: **M** refers to the middle slice (between **R** and **L**). **M** moves in the direction of **L**, and **M'** is its inverse, moving in the direction of **R**.