

Beginner Solution to the Rubik's Cube

Written by Jasmine Lee (<http://peter.stillhq.com/jasmine/rubikscubesolution.html>)

Adapted by James Hamory

Introduction

There are many different methods for solving the Rubik's cube. They can be divided into two broad categories: layer methods and corners first methods (and there are sub-categories within these broad categories). The method I use for speedsolving is a layer based method. More specifically, the method I currently use is: Cross, F2L, 2-look LL. If you are a newbie cuber then this description may not mean much to you, so I should add that it's the advanced solution I described in the "Next Steps" section at the end of this page.

This beginner method requires memorizing only a few algorithms, and when done efficiently can achieve solves of 60 seconds or faster. I know people who can solve in 20-30s with a method like this. It takes a lot of practice to be able to get those times with this trivial method, so don't be too distressed if you can't. On the other hand, if you can do 30s solves with this method, then you are too good for this method and you should be learning an Intermediate or Advanced method!

Aside from minimal memorization, another benefit of this method is that it is very scalable. More algorithms may be added later to develop it into an advanced method, or if you're really keen, an expert method. This means you don't need to scrap it and start again to move to an expert method. Everything you learn here will be useful for more advanced methods.

Structure of the cube

We all know that $3 \times 3 \times 3 = 27$, however, rather than thinking about the cube as 27 little "cubies", think about it as 6 fixed centers (that can rotate on their own axis) with 8 corners and 12 edges which rotate around it. As the centers are fixed, the center color defines the color for the face. It's important to remember this otherwise you'll end up trying to do illogical (mechanically impossible!) things like wondering why you can't work out how to put a corner piece in an edge position, or assuming that you're looking at the blue face merely because 8 of the 9 cubies on it are blue (if the center is white then it's the white face).

Notation

When describing the solution for the 2nd and 3rd layers, standard cube notation will be used. Here's what you need to know to read it:

F = front face **B** = back face **R** = right face **L** = left face **U** = up face **D** = down face

In addition to a letter, each move may be accompanied by an apostrophe or the number two:

- A letter by itself means turn that face 90 degrees clockwise (e.g. **F**).
- A letter followed by an apostrophe means turn that face 90 degrees counter-clockwise (e.g. **F'**).
- A letter followed by the number 2 means turn that face 180 degrees (direction is irrelevant), (e.g. **F2**).

So **R U' L2** is shorthand for "*turn the right face 90 degrees clockwise, then turn the up face 90 degrees counter-clockwise, then turn the left face 180 degrees*". When thinking whether to turn

clockwise/counter-clockwise, imagine that you are looking directly at the particular face you are turning.

For each algorithm, the notation is written with the assumption that the core of the cube remains fixed throughout the whole algorithm, and the faces just turn around it. This means that you also need to know how to position the cube to start the algorithm.

The Solution

The First Layer

The first layer is solved in two stages:

1. Form the cross
2. Insert the 4 first layer corners (each corner is inserted individually)

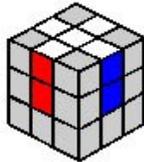
I believe that the first layer should be done intuitively. You need to understand it and solve it without learning algorithms. Until you can do this, I wouldn't bother attempting the rest of the cube! So, spend some time playing with the cube and familiarizing yourself with how to move the pieces around the cube.

Now, here are some tips to get you started.

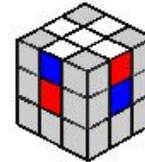
The Cross

I prefer to start with the white cross because I find white easier to quickly identify on a completely scrambled cube, however, you can use any color.

There are 4 edge pieces with white (i.e. the 4 arms of the cross) which have specific positions. You can't put any white edge piece in an arm of the cross because the other color on the edge cubie must match up with it's center on the middle layer.



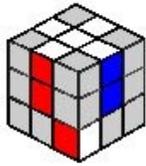
Here is a pic of what a correctly formed cross looks like (grey denotes cubies that are irrelevant to the cross). Note that the **white/red** edge cubie matches up with the **white** center and the **red** center. Same with the **white/blue** cubie.



Here's a pic on an incorrectly formed cross. Looking at the **white** face we do indeed see a **white** cross, however the **white/red** edge cubie does not match up with the **red** center. Same with the **white/blue** cubie. This is bad!

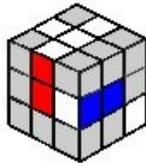
The First Layer Corners

Once you have completed the cross, completing the first layer requires inserting each of the 4 corners in separately. The first thing to do is examine your cube and locate all of the top layer edge pieces - they will be sitting in either the first layer or the last layer. Inserting the first layer corners should be done intuitively, not by learning algorithms. To get you started, here's a step-by-step example of one way to insert a first layer corner.



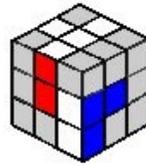
Step 1

The **blue/red/white** corner is sitting in the bottom layer (the **blue** part is facing the bottom so we can't see it in this picture). Turn the **blue** face 90 degrees counter-clockwise.



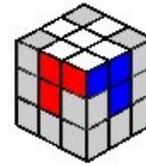
Step 2

Now your cube should look like this. Move the D face 90 degrees counter-clockwise to line up the **blue/white** edge with the **blue/white/red** corner.



Step 3

Now that the **blue/white** edge and the **blue/white/red** corner have been lined up, reform the **white** cross by turning the **blue** face 90 degrees clockwise.

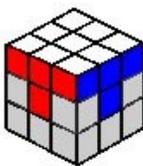


Step 4

Now the **blue/white/red** corner is in its correct place.

Here are some tips for inserting the top layer corners:

- Start with a first layer corner that is sitting in the last layer.
- If there are multiple first layer corners in the last layer (there usually will be), start with one that does not have the white part of the corner on the face opposite the white face. Or, if you were using a different color for the cross ('color X'), start with a corner that does not have the 'color X' part of the corner on the face opposite the 'color X' face.
- When working with a first layer corner piece that is in the first layer (but in the wrong first layer corner position), you will need to get it out of the first layer into the last layer, then insert it into the correct first layer corner position. The same principle applies if a first layer corner piece is in the correct first layer corner position but needs to be flipped around. You need to get it out of the first layer (i.e. into the last layer), and then re-insert it into the first layer the correct way around.



This is what the first layer should look like when finished.

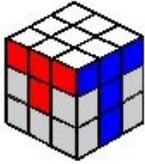
The Middle Layer

The middle layer consists of one stage:

1. Insert the 4 middle layer edges (each edge is inserted individually).

You only need to learn one algorithm (plus the mirror algorithm) for the second layer. There are many more alg's, but let's just learn the essential one first.

First, locate a middle layer edge that is currently sitting in the last layer. I'm going to use the **blue/red** edge for this example.



This blue edge cubie in the last layer is the **blue/red** edge cubie.

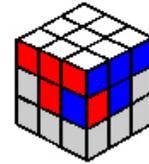
In this picture, **U=white, L=red and F=blue**. We can't see the other three faces, but obviously the R face is the one opposite the L face, the D face is opposite the U face and the B face is opposite the F face.

Now, position the **blue/red** edge piece so that the color on the side of the cube (**blue** in this case) lines up with it's center. Now perform the following algorithm: **D L D' L' D' F' D F**

If the **blue/red** edge piece was flipped the other way so that the **blue** was on the bottom rather than the **red**, you would position the cubie under the **red** center and perform the following alg: **D' F' D F D L D' L'**. This is the mirror of the previous algorithm. The axis of symmetry lies diagonally across the white face, and along the line which divides the **blue** face and the **red** face.

What if the edge piece is not in the last layer?

The instructions above assume that the middle layer edge piece you are inserting is sitting somewhere in the last layer.



If some middle edges are in the last layer and some are in the middle layer in the wrong spot, always start working with the edge pieces that are in the last layer. After you've done this, sometimes (but not too often) you'll be left with a middle layer edge piece that's in the middle layer but in the wrong spot. In this situation, you can use the same middle layer algorithms from above (**D L D' L' D' F' D F** or **D' F' D F D L D' L'**) to insert another edge piece into the middle layer edge position, thereby knocking the middle layer edge piece out of its spot and into the last layer. Once you've done this, the middle layer edge piece is in the last layer and you can deal with it in the usual way.

*The **red/blue** middle layer edge piece is in the middle layer but not oriented correctly. It needs to be moved to the last layer, then put back into the middle layer in the right way.*

There is a short-cut to this problem, but as this is a beginner solution with minimal memorization, I haven't included it here.

The Last Layer

The last layer ("LL") is done in 2 steps, each with two sub-steps, meaning 4 total steps:

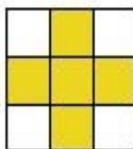
1. Orientation of the Last Layer ("OLL")
 - a. Orient the edges (2 algs) - i.e. form a cross on the D face.
 - b. Orient the corners (2 algs) - i.e. flip the corners
2. Permutation of the Last Layer ("PLL")
 - a. Permute the corners (1 alg) - i.e. get the corners in the correct position in 3D space
 - b. Permute the edges (1 alg + inverse) - i.e. swap the edges around. The cube will then be solved! :)

All last layer algorithms are performed with the cross (i.e. the first layer - white side in this example) on the bottom.

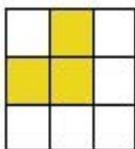
Orienting the LL Edges

Once you have completed the first two layers ("F2L"), hold the cube so that the white side is on the bottom. The white side will be on the bottom for the remainder of the solution. This means that the white side is the D side for all last layer algorithms.

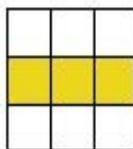
On my cube, white is opposite yellow, therefore yellow is the U face for all last layer algorithms on my cube. Note that your cube may have a different color opposite white (e.g. blue). Now have a look at your last layer, and in particular, look at the last layer face - there are 4 possible patterns of LL edges that you may see.



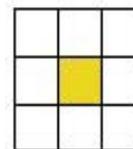
State 1



State 2

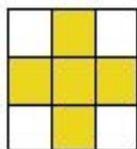


State 3



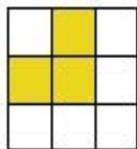
State 4

Unlike with the initial cross (where all the edges must match up with the white center and with the centers on the middle layer), here all you need to worry about is getting all the last layer edges matching up with the last layer center. It doesn't matter if the other color on the LL edge piece does not match up with the color on the middle layer center. Also, ignore the LL corners too. It doesn't matter what they are doing at the moment. Now, let's consider each of these LL edge states separately.



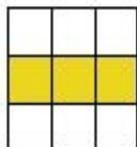
State 1

All the edges are already oriented correctly. Move on to orienting the corners.



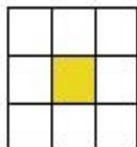
State 2

We are going to re-orient our faces for this algorithm. The face you are looking directly at in this picture is now the U face (it was the D face for when you were doing the second layer edges). Perform the following algorithm: **F U R U' R' F'**



State 3

As with State 2, the face you are looking directly at in this picture is now the U face. Perform the following algorithm: **F R U R' U' F'**

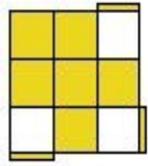


State 4

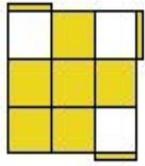
State 4 is really a combination of States 2 and 3, so all you need to do is perform the algorithm for either State 2 or State 3. Once you've done this, you'll see that your LL edges now look like State 2 or State 3, so just perform the appropriate algorithm and you will have a cross on the LL.

Orienting the LL Corners

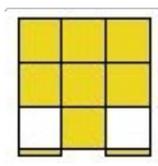
There are 8 possible orientation states for the LL corners. One is where all 4 corners are correctly oriented. The other 7 look like this.



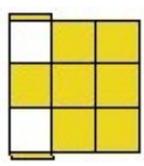
State 1



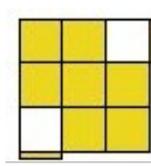
State 2



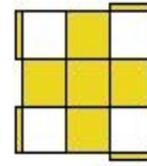
State 3



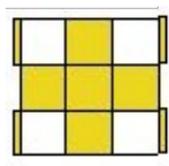
State 4



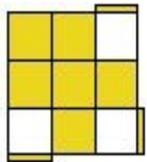
State 5



State 6



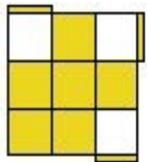
State 7



State 1. Twisting three corners counter-clockwise

$R' U' R U' R' U^2 R$

This algorithm is known as the Anti-Sune.



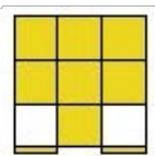
State 2. Twisting three corners clockwise

$R U R' U R U^2 R'$

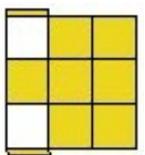
This algorithm is known as the Sune.

States 3-7

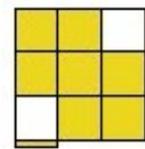
Once you know the algorithms for States 1 and 2, you can solve any LL orientation State. The remaining States can be oriented using a maximum of 2 algorithms. You will need to do one of the following (i) the State 1 algorithm twice, (ii) the State 2 algorithm twice, (iii) the State 1 algorithm, then the State 2 algorithm, or (iv) the State 2 algorithm, then the State 1 algorithm.



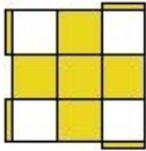
State 3: Sune, then Anti-Sune ($R U R' U R U^2 R'$, then $R' U' R U' R' U^2 R$)



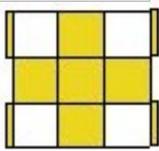
State 4: Sune, U^2 , Anti-Sune ($R U R' U R U^2 R'$, U^2 , $R' U' R U' R' U^2 R$)



State 5: Sune, U , Anti-Sune ($R U R' U R U^2 R'$, U , $R' U' R U' R' U^2 R$)



State 6: Sune, U', Sune ($R U R' U R U^2 R'$, U' , $R U R' U R U^2 R'$)



State 7: Sune x2 ($R U R' U R U^2 R'$) x2

Permuting the LL Corners

The two possible states are:

- two adjacent LL corners need to be swapped; or
- two diagonal LL corners need to be swapped.

These are the only two possible states. If you cannot identify one of these two states with your LL corners then one or more of the following must be true:

- You have not finished the F2L.
- Someone has ripped out a corner of your cube and put it in the wrong way.
- Someone has ripped off some of your stickers and put them back in the wrong place.
- You are not looking hard enough. ;)

Swapping adjacent corners

Hold the cube with the white side on the bottom, and the two corners to be swapped are in the front right top and the back right top positions. Perform the following algorithm: $L U' R' U L' U^2 R U' R' U^2 R$. This algorithm is known as the L Perm. It swaps the UFR and UBR corners and the UR and UB edges. You do not need to worry about how the edges move around in this step because you will be solving the edges in the next step anyway.

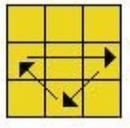
Swapping diagonal corners

Swapping diagonal corners can be done by executing the adjacent corner swap algorithm twice. Perform it once to swap any two LL corners. Re-examine the cube and you'll see that now there are just two LL corners that need to be swapped. Position it correctly for the final LL adjacent corner swap and perform the LL adjacent corner swap algorithm.

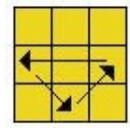
Permuting the LL Edges

There are 5 possible permutation states for the LL edges. One is where all 4 edges are correctly permuted. The other 4 look like this.

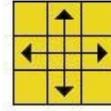
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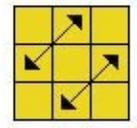
State 1



State 2



State 3



State 4

**R2 U R U R' U' R' U'
R' U R'**

This is the Ua Perm. It cycles 3 edges clockwise:

UR>UF>UL

**R U' R U R U R U' R'
U' R2**

This is the Ub Perm. It's just the Ua Perm backwards. It cycles 3 edges counter-clockwise:

UL>UF>UR

Apply the algorithm for either State 1 or State 2. Re-examine your cube and it will now look like State 1 or State 2.

Apply the algorithm for either State 1 or State 2. Re-examine your cube and it will now look like State 1 or State 2.

And that's all you need to know to solve the Rubik's Cube! With practice, you should be able to achieve times of 60 seconds (or faster) using this method. Once your comfortable with this method and want to learn more, take a look at the following section.

Next Steps

If this beginner method is too easy and boring for you then check out the following.

<http://cubeflip.webs.com/solutionsdownloads.htm> James Hamory's Intermediate and Advanced solutions

http://www.speedsolving.com/wiki/index.php/Main_Page Wikipedia for cubing? Very helpful.

http://www.speedsolving.com/wiki/index.php/Competitions_General Information about Official WCA (World Cube Association) Rubik's Cube Competitions!

Celebrate your cubing success!

When you are confident that you can solve the cube by yourself, time yourself so you can keep track of your progress.