Beginner Solution to the Rubik's Cube

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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, 3-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.

There are many great websites that explain intermediate, advanced and expert methods for solving the cube (check out my **Rubiks links** page). However, there are very few that explain beginner methods, which is why I wrote this. It's not meant to be a totally comprehensive explanation, it's really just some notes I threw together for some friends I was teaching. I thought it might be useful for others, so I've turned it into a webpage.

This beginner method requires memorising only a few algorithms, and when done efficiently can achieve solves of 60 seconds or faster. I know people who can solve in 30s with a method like this. I, personally, have not done 30s with this method though, so don't be too distressed if you can't either. 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 Advanced method!

Another benefit of this method is that it is fairly scalable, so more algorithms may be added later to develop it into an advanced method, or if you're really keen, an expert method.

Structure of the cube

We all know that 3x3x3=27, however, rather than thinking about the cube as 27 little "cubies", think about it as 6 fixed centres (that can rotate on their own axis) with 8 corners and 12 edges which rotate around it. As the centres are fixed, the centre colour defines the colour 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 centre is white then it's the white face).

Terminology

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

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

For pictures and further detail about cube notation, have a look at **Jon Morris' cube notation page**.

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)

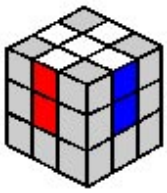
I believe that the first layer should be done intuitively. You need to understand it and solve it without learning algorithms. Until you can do this, I wouldn't bother attempting the rest of the cube! So, spend some time playing with the cube and familiarising yourself with how to move the pieces around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

Now, here are some tips to get you started.

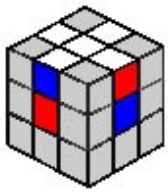
The Cross

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 colour.

There are 4 edge pieces with white (ie. 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 colour on the edge cubie must match up with it's centre 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** centre and the **red** centre. Ditto re the **white**/**blue** cubie.

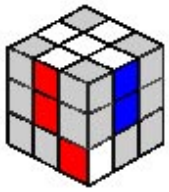


Here's a pic on an incorrectly formed cross. Looking at the **white** face we do indeed see a **white** cross, however the **white**/**red** edge cubie does not match up with the **red** centre. Ditto re the **white**/**blue** cubie. This is bad!

For a detailed explanation of the cross, check out Dan Harris' **Solving the Cross** page.

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 top layer or the bottom layer. Inserting the top 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 top layer corner.



Step 1

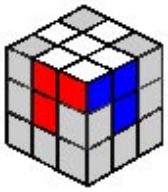
The **blue**/**red**/**white** corner is sitting in the bottom layer (the **blue** part is facing the bottom so we can't see it in this picture). Turn the **blue** face 90 degrees anti-clockwise.

Step 2

Now your cube should look like this. Move the D face 90 degrees anti-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, re-form 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 top layer corner that is sitting in the bottom layer.
- If there are multiple top layer corners in the bottom layer (there usually will be), start with one that does not have the white part of the corner on the D face. Or, if you were using a different colour for the cross ('colour X'), start with a corner that does not have the 'colour X' part of the corner on the D face.
- When working with a top layer corner piece that is in the top layer (but in the wrong top layer corner position), you will need to get it out of the top layer into the bottom layer, then insert it into the correct top layer corner position. The same principle applies if a top layer corner piece is in the correct top layer corner position but needs to be flipped around. You need to get it out of the top layer (ie. into the bottom layer), and then re-insert it into the top 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 algs, 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 colour on the side of the cube (**blue** in this case) lines up with it's centre. 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** centre 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.*

The Last Layer

The last layer ("LL") is done in 4 steps:

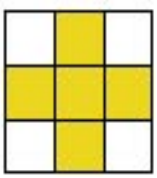
(1) Orient the edges (2 algs) - ie. form a cross on the D face
(2) Permute the corners (1 alg) - ie. get the corners in the correct position in 3D space (don't worry if they still need to be rotated)
(3) Orient the corners (1 alg + mirror alg) - ie. flip the corners
(4) Permute the edges (1 alg) - ie. swap the edges around. The cube should now be solved! :)

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

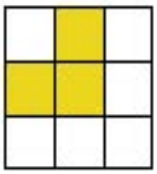
Orienting the LL Edges

Once you've 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.

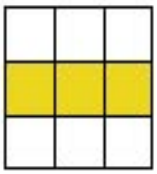
On my cube, white is opposite yellow, therefore yellow is the U face for all last layer algorithms on my cube. Note that your cube may have a different colour opposite white (eg. blue). Now have a look at your last layer, and in particular, look at the last layer face -- there are 4 possible patterns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



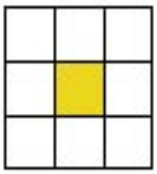
State 1



State 2

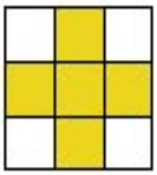


State 3



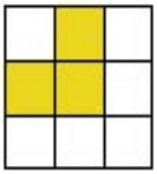
State 4

Unlike with the initial cross (where all the edges must match up with the white centre and with the centres on the middle layer), here all you need to worry about is getting all the last layer edges matching up with the last layer centre. It doesn't matter if the other colour on the LL edge piece does not match up with the colour on the middle layer centre. 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.



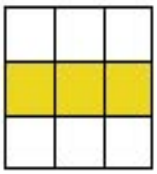
State 1

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



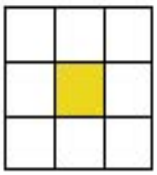
State 2

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.

Permuting the LL Corners

The two possible states are: (i) two adjacent LL corners need to be swapped; or (ii) 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 of the following must be true (i) you have not finished the F2L; (ii) someone has ripped out a corner of your cube and put it in the wrong way; (iii) someone has ripped off some of your stickers and put them back in the wrong place; or (iv) you are not looking hard enough. ;)

Swapping adjacent corners

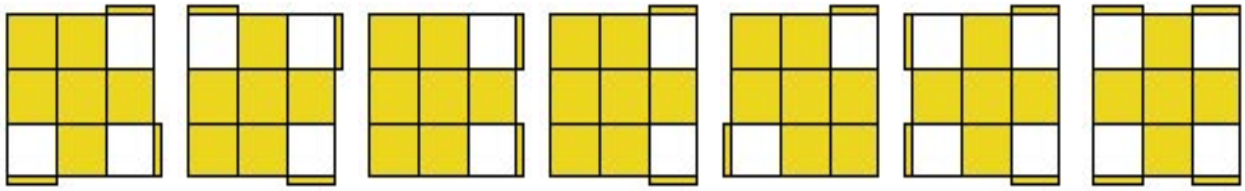
Hold the cube with the white side on the bottom, and the two corners to be swapped are in the front right top and the back right top positions. Perform the following algorithm: **L U' R' U L' U' R U2**

Swapping diagonal corners

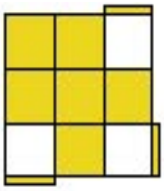
Swapping diagonal corners can be done by executing the adjacent corner swap algorithm twice. Perform it once to swap any two LL corners. Re-examine you cube and you'll see that now there are just two LL corners that need to be swapped. Position it correctly for the final LL adjacent corner swap and perform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

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.

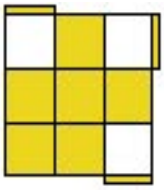


State 1 **State 2** **State 3** **State 4** **State 5** **State 6** **State 7**



State 1. Twisting three corners anti-clockwise

R' U' R U' R' U2 R U2



State 2. Twisting three corners clockwise

R U R' U R U2 R' U2

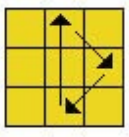
States 3-7

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.

I'm not going to tell you which of these options should be used for which remaining State because it's important that you try to understand how the State 1 and the State 2 algorithms work. Once you understand these algorithms you will be able to work out how to use them to solve all the States.

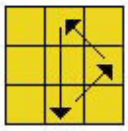
Permuting the LL Edges

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



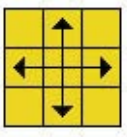
State 1

R2 U F B' R2 F' B U R2



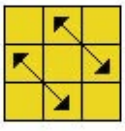
State 2

R2 U' F B' R2 F' B U' R2
This is almost identical to the algorithm for State 1. Only difference is the 2nd move and the 2nd last move.



State 3

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.



State 4

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 really need to know to solve the Rubik's Cube! With practice, you should eventually 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 consider the following.

Intermediate method

- Solve each first layer corner + corresponding middle layer edge in one step. This means that, after the cross, you only have 4 steps (4 corner/edge pairs) to complete the F2L. With this beginner method there are 8 steps (solve each of the 4 first layer corners, then solve each of the 4 middle layer edges). I'd suggest just playing around with your cube and figuring out the F2L corner/edge pairs yourself. For some hints about solving the F2L intuitively, have a look at **Doug Reed's intuitive F2L guide**. If you're still stuck and just want the algs, check out **Dan Harris' F2L page** and **Jessica Fridrich's F2L page**.
- Learn the 4 specific algorithms (or rather, 3 algorithms plus one mirror algorithm) for each of the 4 different permutation states of the LL edges.

For more details about the intermediate method, check out **Dan Knights' intermediate solution**.

Advanced method

- Learn everything from the Intermediate method.
- Learn the 3-look LL. This requires learning the 7 specific algorithms for the 7 different orientation states of the the LL corners, and learning the 21 PLL algorithms (permuting the last layer algorithms) so you can permute the LL edges and LL corners at the same time. A full 3-look LL uses 30 algorithms.

For more details about the advanced method, check out **Dan Knights' advanced solution** and **Jessica Fridrich's LL permutations**.

Expert method

- Do the F2L in 5 steps (first dot point from the Intermediate method).
- Learn a full 2-look LL. This requires memorising 21 PLL algorithms, plus 57 OLL algorithms (orienting the last layer algorithms).

For more details about the expert method, check out the **Speedcubing.com LL algorithm page**, **Dan Harris' site** and **Jessica Fridrich's site**.

Other stuff

The method I've documented here is what I believe to be a good beginner method. The problem with some beginner methods is that they are not scalable - to improve your cubing you have to un-learn much of what you know and re-learn it in a different way. This method focuses on memorising very few algorithms, but is structured in a way that allows for development into an intermediate or advanced method. Other thing I should say is that I didn't actually devise any of the last layer algorithms in this method. I merely chose a selection of existing algorithms (sourced from a variety of places including **Jessica's site** and **Dan K's site**) and organised them into a simple solution method.

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. Also, consider submitting your time to the **unofficial world records**.