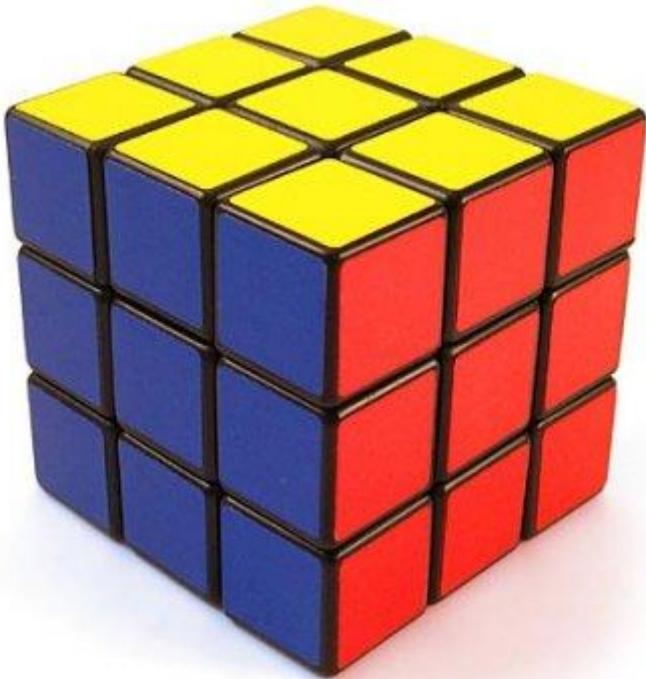


How to solve a 3x3x3 Rubik's Cube



By Daniel Sheppard

Introduction

This is a guide to solving the best-selling toy of all-time – the 3x3x3 Rubik's Cube. Whilst it looks like an incredibly hard task on first glance, it is actually fairly easy to learn a basic solving method. Anything in *italics* is more advanced and is not needed to solve the cube.

Concepts and Notation

The solve will be done in 3 main stages, each divided into smaller steps.

Stage 1: First Layer

Stage 2: Second/Middle Layer

Stage 3: Last Layer

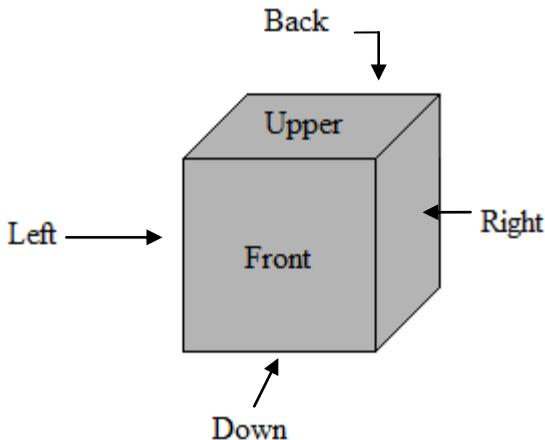
There are 3 types of pieces on a cube.

1. **Middle/centre pieces** – these are the pieces in the centre of each of the 6 faces. There are obviously 6 of them and they don't move relative to each other i.e. white is always opposite yellow, orange opposite red and green opposite blue. They define the colour that each face will be when the cube is solved.
2. **Edge pieces** – these are the pieces with 2 colours on, and are found on each of the 12 edges of the cube.
3. **Corner pieces** – these are the 8 pieces on the corners of the cube, and each of them has 3 colours on.

There are 43,252,003,274,489,856,000 (43 quintillion) different positions that the cube can be scrambled into

Concepts and Notation (continued)

There are 6 faces on the cube – we shall label them like so:



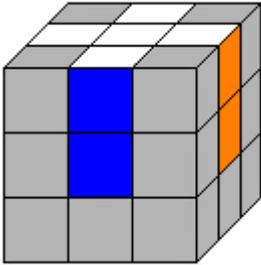
The notation for turning instructions is as follows:

- Each face is denoted by the first letter in it's name (F,U,R,L,B,D)
- U – turn the Upper face 90° clockwise as if you were looking at the face
- U' – same thing, but 90° anticlockwise
- U2 – same thing, but 180° turn (doesn't matter which way!)

One last thing to do before you start to solve the cube – scramble it! To do this, just turn random faces in random directions about 30-40 times.

Stage 1.1: The White Cross

Below is a picture of what the cube will look like at the end of this stage. The grey pieces indicate that it doesn't matter what is in those places.



Feel free to try and do this stage without the instructions – many people can do it without guidance.

I would recommend learning to solve the white since first as it is the easiest colour to spot. Always sticking to solving one colour first will help you to spot the right pieces faster when you are trying to improve your solving time.

This stage involves putting the 4 edge pieces with white on into place. As a beginner you want to focus on one edge piece at a time. *Advanced Tip: Try to look at multiple edges at a time to save moves.*

The most important thing to remember is that the edges have to match up with the correct middle pieces i.e. the white and blue edge piece has to be on the edge between the white centre piece and the blue centre piece as it is in the picture.

Do this stage keeping the white face (the face with a white piece in the middle) as the 'upper' face. Obviously you can look around the cube, but always try not to lose your orientation by having white on top.

The White Cross (continued)

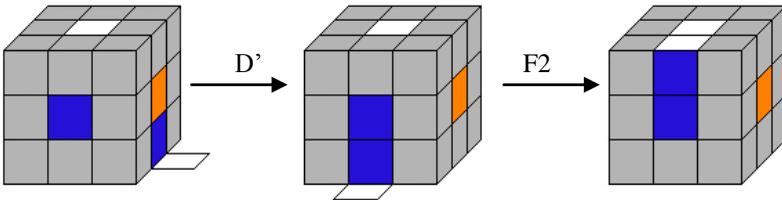
The first thing to check is whether there are already any white edge pieces on the white 'upper' face. If there are, you want to do turns of the upper face until the non-white sticker connects up with the correct middle piece (either blue, orange, green or red).

As was said, you want to put in one piece at a time so find an edge (not corner!) piece and try to put it in the right place. While you put the pieces in place look at what's happening carefully so that next time you can just do it intuitively and you won't need to follow any set moves.

Below are the moves for the different cases.

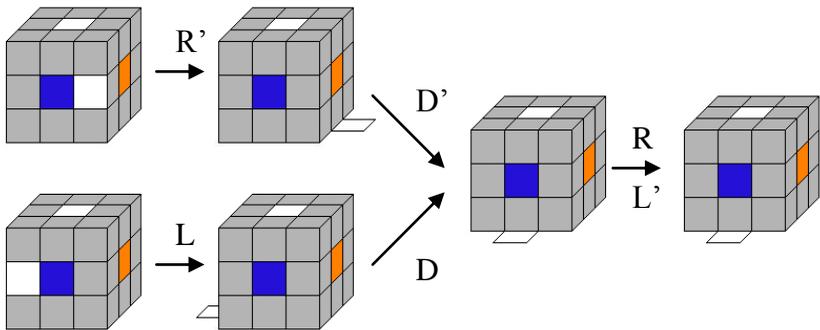
Case 1: Edge piece has white sticker on the D face

1. Turn the D face until the piece connects to one of the side middle pieces
2. Do a double turn of that side so that the white is now on top and in the right place



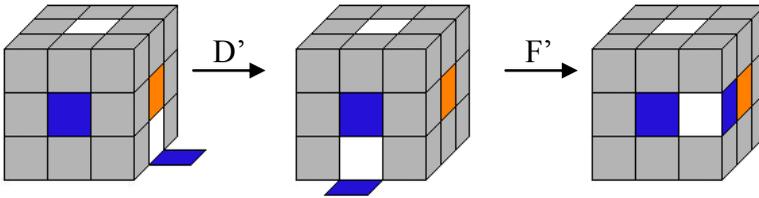
Case 2: Edge piece has white sticker on the side

1. Hold the cube so that it looks like one of the 2 situations below
2. Turn either the left or right face so that the white sticker goes underneath the cube
3. Turn the D face so that the edge piece moves to the front
4. Undo the move from 2
5. You now have case 1



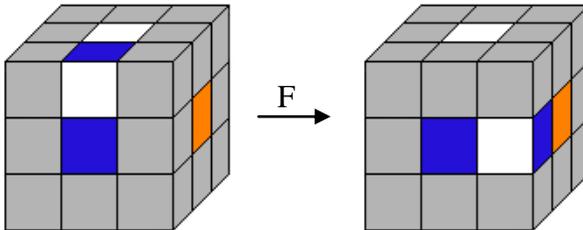
Case 3: Edge piece is on the bottom layer but the white sticker is on one of the side faces

1. Turn the D face until the edge piece is underneath where it wants to go
2. Turn the front face once
3. You now have case 2

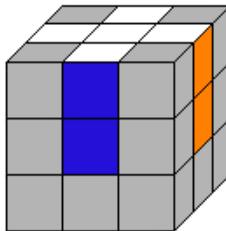


Case 4: Edge piece is on U layer but white sticker is not on top

1. Hold the cube so that the white sticker is on the front face
2. Turn the front face once
3. You now have case 2



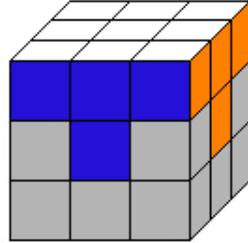
Do all 4 white edge pieces and you have then completed stage 1.1. The cube should look like this:



Once the cube has been scrambled there is a 1 in 190,080 chance that the white cross will already be there

Stage 1.2: The White Corners

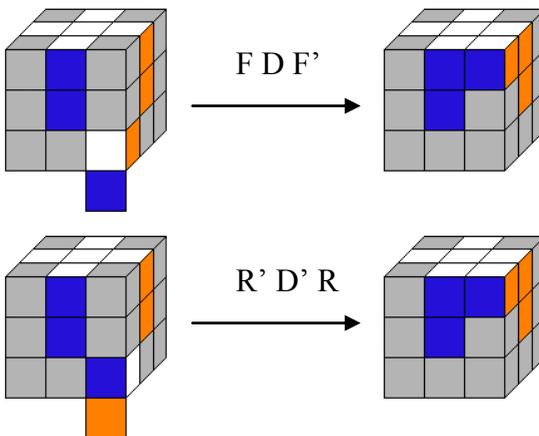
This is the second and final part of stage 1. This is what the cube will look like when the stage is complete:



Once again we work on one piece at a time.

Case 1: Corner piece is on D layer and white sticker is on a side face

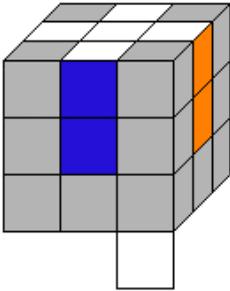
1. Turn the D face until the corner is directly below where it needs to go i.e. if it is white, blue and orange then it should be positioned between the blue and orange faces
2. Hold the cube in one of the positions below and then execute the corresponding moves



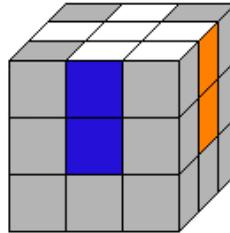
Every other situation will just be reduced to case 1 and here's how to do that.

1. Hold the cube in one of the positions below
2. Execute $R' D' R D$ over and over again until you have case 1

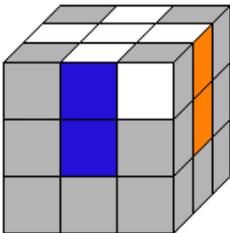
Advanced Tip: The above method works but is not very efficient. Below the situations are quicker ways to reduce to case 1. Try to look carefully at how you're moving the piece around while you do the moves.



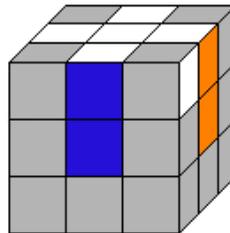
$R' D_2 R$



$R' D' R$



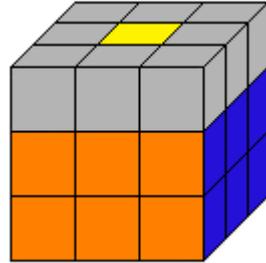
$F D F'$



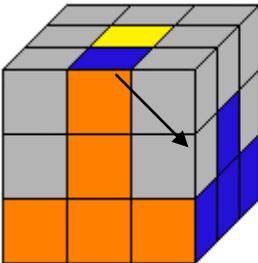
$R' D' R$

Stage 2: The Second/Middle Layer

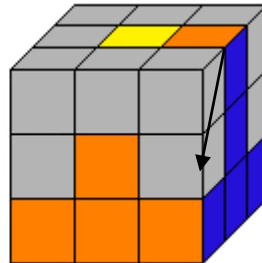
Because we've finished the white face we turn the cube over so that the whites are underneath, and this is the way that we will keep the cube from now on. There is just one algorithm (set of moves) to learn for this stage, and there are just 4 edge pieces to put into the middle layer because the centre pieces are already in place.



1. Find a piece in the top layer which needs to go into the middle layer. (Every piece that goes in the first layer has been done already, and every piece that goes in the last layer will have yellow on. So, all we need to look for is an edge piece with no yellow on the top layer).
2. Turn the U face until the edge piece matches up with a centre piece.
3. Hold the cube in one of the positions below and execute the corresponding algorithm.



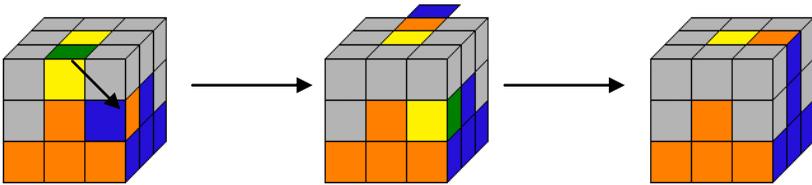
$URUR'U'F'U'F$



$U'F'U'FURUR'$

Note that one is just the mirror image of the other. Also note that after 4 moves the white face is still complete apart from one corner piece. You can just do those 4 moves and then pretend that you're putting the corner back in like in case 1 of stage 1.2.

One other situation you might come across is if the edge piece is in the right place but flipped the wrong way round. In this case you just pick a random other piece on the top layer and 'pretend' that this one needs to go into that slot. In putting that one in you will bring the correct piece onto the top layer, from where you can put it back in the right way round.



Take a pretend piece on the top layer (in this case yellow and green) and put it in the slot

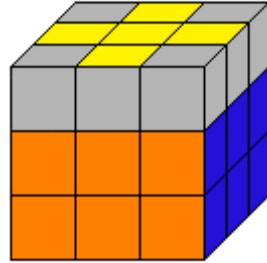
Now the piece you want is on the top and you can line it up and put it in

Do exactly the same thing if there are no pieces on the top layer that need to go in the middle layer.

Once you've done all 4 edge pieces you have completed 2 layers of the cube! Just one layer to go...

Stage 3.1: Make a Yellow Cross

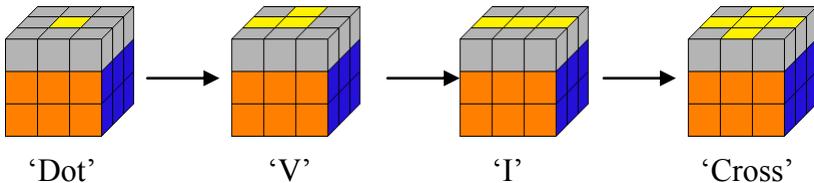
The last layer is split into 4 parts – the first 2 get the yellow edges in place and the last 2 look at the corners. Each part only requires 1 algorithm, none of which are longer than 8 moves.



After this part the cube will look like the picture on the right. If, at any point before a part, you find that your cube already looks like it should after doing the part (e.g. if your cube already has a yellow cross after finishing the middle layer) then you've got lucky and you can skip to the next part!

Algorithm: $F R U R' U' F'$

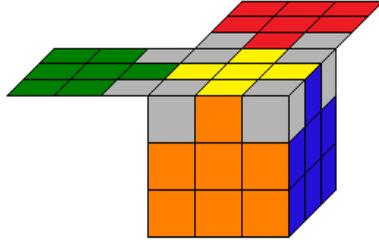
This will have to be done 1-3 times depending on what the top layer is like after the previous stage. Below are the diagrams of which way round to hold the cube and how you move towards the cross.



Advanced Tip: Move straight from 'V' to 'Cross' using this algorithm: $F U R U' R' F'$.

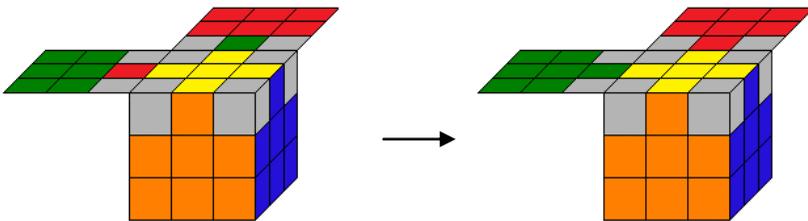
Stage 3.2: Correct the Yellow Cross

This stage moves the pieces of the yellow cross around so that they match up with the middle pieces. As always, here's a picture of the post-part cube:



1. Currently you can turn the U face without affecting anything that has already been put in place. To set up this part you turn the U face until you get 2 adjacent yellow edge pieces matching up on their correct faces (such as the orange and blue ones above). If the other 2 are also in the right place when you do this then you can skip the stage! If not, then the other 2 just need swapping over. Sometimes you won't be able to get 2 next to each other that match up. If this happens just do the algorithm once and then try again – you should be able to find 2 next to each other now.
2. Hold the cube so that the 2 that need swapping over are on the left and back faces. Then execute the algorithm and you're all done.

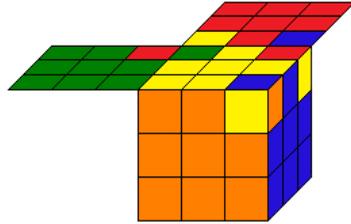
Algorithm: R U R' U R U² R' U



Marcin Kowalczyk (POL) memorised 41 scrambled cubes and then put blindfold on and solved them all without looking!

Stage 3.3: Place the Yellow Corners

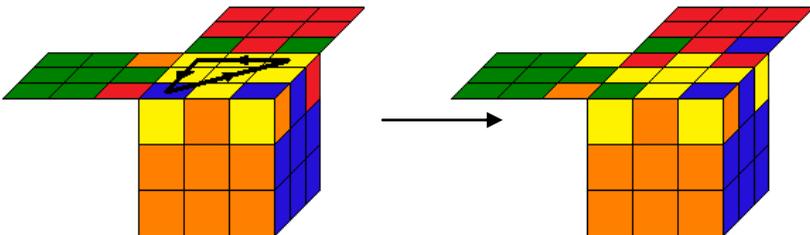
This (penultimate) part puts the 4 corners in the right place, but we are not bothered whether the yellow sides are facing up or not yet. So the cube might look something like this afterwards:



1. Unlike the previous part we can't freely turn the U face anymore. So, we just look around for a corner piece that's in the right place (it doesn't have to be facing the right way up – it just needs the right 3 colours). Hold the cube so that the corner is between the front and right faces.
2. Execute the algorithm. The algorithm moves the other 3 corners around in an anticlockwise direction, so you may need to do it twice. *Advanced Tip: Do the algorithm backwards if the corners need to go clockwise – $L'URU'LU R'U'$*

As before, if you can't find a corner in the right place just do the algorithm once and then there will be one in the right place.

Algorithm: $URU'L'UR'U'L$



Stage 3.4: Twist the Yellow Corners

I don't need to show you a picture of what the cube will look like after this stage because it will be solved! It's the easiest algorithm to learn (only 4 moves) but it is an easy place to get everything very wrong!

Algorithm: R' D' R D

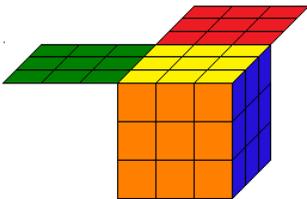
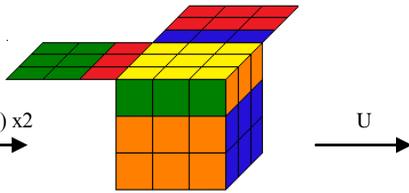
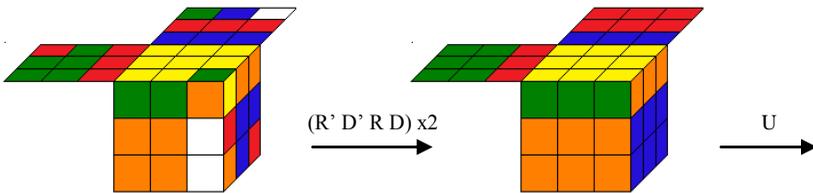
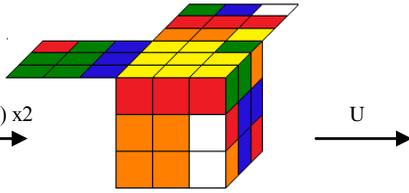
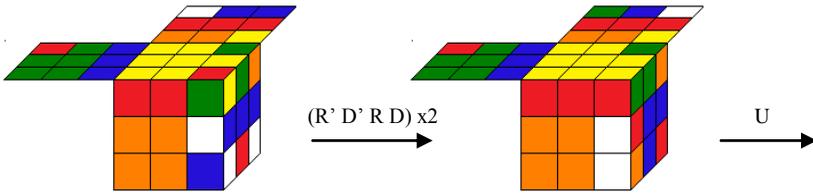
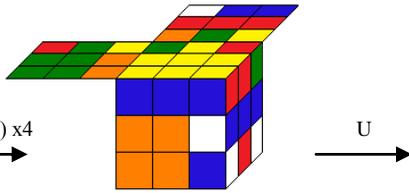
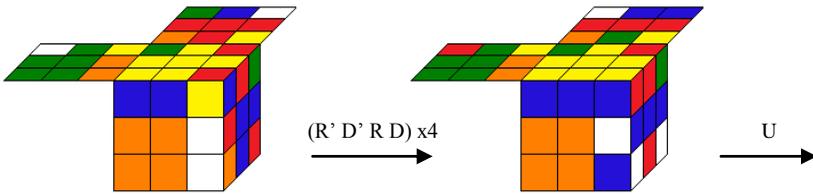
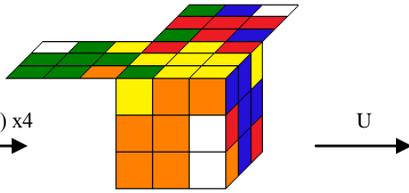
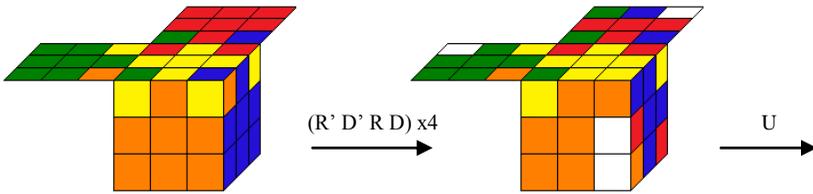
You will work on one corner at a time – always the one that's between the front and right faces.

1. Do the algorithm above over and over again until the yellow sticker piece is facing upwards (the right way up) – you'll have to do it either 2 or 4 times.
2. Do the move U so that the next corner comes to be between the front and right faces.
3. Repeat steps 1 and 2 until all 4 corners have been twisted
4. A few trivial turns will be done at the very end and the cube is now solved!

An example of what sort of thing you might have to do is on the next page.

After doing one corner you'll find that the cube looks quite scrambled, but don't worry, carry on and it should all come back together once you've done all the corners. If it doesn't then sorry, but you'll have to start again!

Advanced Tip: If you realise that you're going to need to do the algorithm 4 times then just do it twice backwards – D' R' D R.



Congratulations...you
have solved the cube!

Appendices

Algorithm Reference Page

Middle Layer:

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

Make a Yellow Cross:

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

Correct the Yellow Cross:

R U R' U R U² R' U

Place the Yellow Corners:

U R U' L' U R' U' L L' U R U' L U R' U'

Twist the Yellow Corners:

R' D' R D D' R' D R

Some Fun Algorithms!

6 Centre Swap:

R L' D U' F B' R L'

3 Colour Swap:

U R² L² F B R' L U D F U' R² L² F² B² D' L² D² L² U²

Mini Block Twist:

U R² D L F' L F' L F' D' R² U L² B² U²

2 Rings:

F² D' R² D' L' U' L' R B D' U B L F² L U²

Anaconda:

L B² D R B' F D' L' R D' U F' R² U'

Greek Labyrinth:

U' B² L B' L' U² B' U' L F L² U F U' F² L

Connected Rings:

U F² U' L² F' U R' U² R U' F' R² U' L² F² D' B²

Where do I go from here?

Once you have managed to solve the cube, what should you do?

1. Memorise the method. This can be done fairly easily just by solving the cube a few more times.
2. If you're interested in becoming quicker you should look at the *advanced tips*.
3. Start timing yourself so that you can have records to aim at. There are 2 ways of getting faster – learning more moves and improving speed.
4. Figure out some good 'finger tricks' where you use fingers rather than the whole hand to turn faces.
5. Once you've got your average down to about 50-60 seconds you should start to think about learning some new moves. You will find that most of the top cubers use the CFOP method.
6. The first part of the CFOP method to learn is F2L (first 2 layers). This is when you do the white cross but then combine the next 2 stages by putting in the white corners with their corresponding middle pieces. At first when you learn these moves you will find that you are very slow – but don't worry, with enough practice you'll find that your time eventually comes back down and past where it was.
7. Once you've got down to about 40 seconds you might consider learning another part of the CFOP method called PLL.
8. At 30 seconds it would be time to start learning OLL. Once you've learnt this you will basically be using the same method that the fastest cubers in the world use (<10 second average).

Web Pages

Shops

High Street Shops – I would not recommend buying an ‘official’ Rubik’s cube from a shop because they cost around £10-15 which makes them at least as expensive as anything on the internet and they don’t turn as well as other cubes anyway!

<http://ukcubestore.com/> - Best UK site for buying twisty puzzles.

<http://thecubicle.us/> - A great US store with lots of accessories as well.

www.rubiks.com - Official Rubik’s Cube site.

www.cubsmith.com - Useful for buying replacement stickers and parts

Info

www.worldcubeassociation.org - Official site for competitions and records

<http://www.ukca.org/> - The UK Cube Association site

www.speedsolving.com/wiki - Loads of useful info here and plenty of links to other sites

www.cubefreak.net – Great site for the CFOP (Fridrich) method and blindfold solving

Resources

<http://mzrg.com/qqtimer/> - Online timer with scramblers for all puzzles

www.superliminal.com/cube/cube.htm - The site with a 4D and 5D simulator

There are many other downloadable timers and resources linked on the SpeedSolving wiki.