

Wrestling with Rubik's Cube

Rubik's Cube is the award winning mechanical puzzle invented by the Hungarian sculptor and professor of architecture Ernő Rubik. Since its introduction in 1974, over 100 million Rubik's Cubes were sold in the period from 1980 to 1982 alone. This magic puzzle cube has frustrated millions of people since its release. But don't worry! You can learn how to solve the Rubik's cube following my easy-to-follow steps outlined here.

Study this solution guide with hands-on exercise and learn how to solve the amazing Rubik's Cube - puzzle and keep your brain stimulating. Have fun while challenging your intelligence and motor skill.



Author's Note:

My first encounter with Rubik's cube was in early 1980 when as a young engineer I was working for an automotive company in Warren, Michigan. Among friends at work, it was a cool thing to get into this, by then already world famous, toys. Like many in the group, after some struggle, I was able to follow a set of instruction to solve the cube. As the glare died down, even my last notes on solving the cube was lost in my files of my reports and folders. In Christmas of 2007, I got myself a Rubik's cube again and started to play with it.

Unlike in the 1980's, now you can search for solution to Rubik's Cube and be overwhelmed with a number of sites and documentation. It doesn't make the job any easier, however. You still have to devote a good deal of time to learn to play with it first, and then think about solving it. Like many others, I studied some solutions, practiced it, and thought that I would attempt show others how to enjoy solving the cube.

- ROYRK , Bloomfield Hills, MI. August 2008

Overall Strategy

1. Become comfortable with the cube and learn the move notations.
2. Build complete cube one layer at a time, starting with the first layer. Assemble the CROSS first, and then the four corners (See Phase IV).
3. Assemble the second layer by placing the four edge pieces in the correct position (Phase V)
4. Finish the third layer without disturbing the first and second layers you already done. Make the CROSS first, and then finish the corners (Phase VI)

Note: The attached long descriptions (Six Phases) are for ease of learning and for first timers. After you have solved it once, all you will need is a set of moves in a pocket size card.

Phase 1: Getting to know the cube

In the approach demonstrated here, you will learn to solve the cube in the following six phases, arranging the pieces layer at a time.

Rubik's cube (3x3x3) has 26 pieces and SIX faces. From any orientation you look/hold, it has THREE LAYERS (or slice). The UPPER and DOWN (bottom) has 9 pieces each, and the MIDDLE layer has 8 pieces (Center pieces are fixed).

Notation:

L = Left Layer
 R = Right Layer
 U = Top Layer
 D = Down Layer
 F = Front Layer
 B = Back Slice

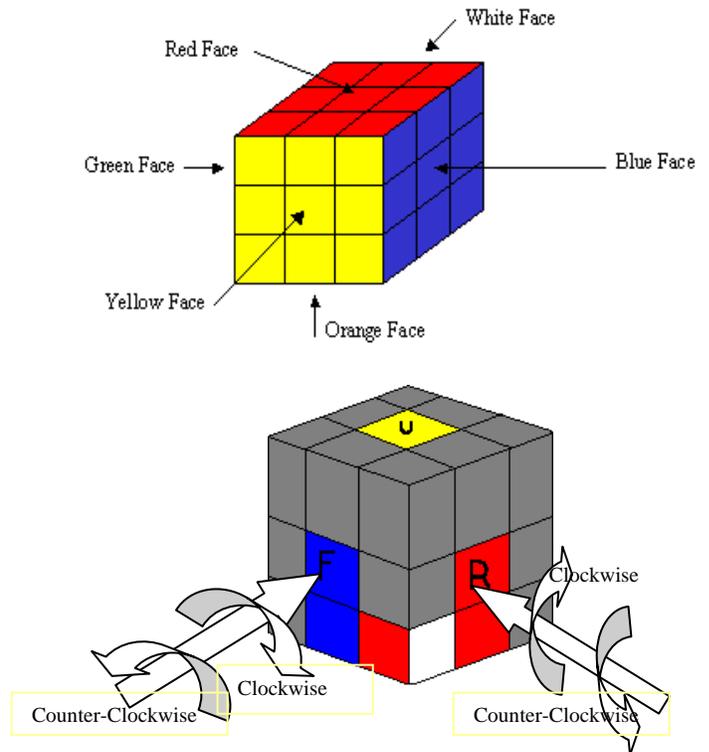
H = Horizontal-Center Slice
 M = Middle Center Layer
 (No moves associated with H and M)

- R in a formula represents CLOCKWISE turn of the RIGHT layer (90 degrees)
- R' in formula represents a COUNTER-CLOCKWISE rotation of the RIGHT layer (90)
- F2 represents CLOCKWISE rotation of FRONT layer twice (90 + 90 degrees)

To determine CLOCKWISE or COUNTER-CLOCKWISE rotation, look straight at the face.

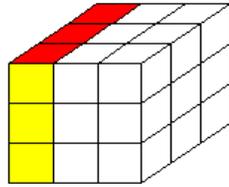
Cube Face Colors: (In the cube used here)

WHITE is opposite to YELLOW
RED is opposite to ORANGE
BLUE is opposite to GREEN

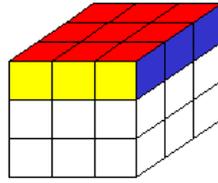


- **Center pieces** – There are six center pieces, one in each face (side) of the cube. The six sides have colors: White, Blue, Green, Orange, Red, and Yellow. These center pieces,
 - Have only one face
 - Rotate, but do not move
 - Face color is based on the color of the center piece. For example, a BLUE face is the face with BLUE center piece, regardless of the color of the other pieces.
- **Edge pieces** – There are 12 edge pieces. These pieces,
 - Have two faces, one in each of the six face colors
 - Can occupy any of the 12 positions in any orientation
 - Cannot be moved to corners (or center) positions.
- **Corner pieces** – There 8 corner pieces. These pieces,
 - Have three faces each in three different colors
 - Each can occupy any of the 8 corners of upper and down layers
 - Each can be positioned in any orientation

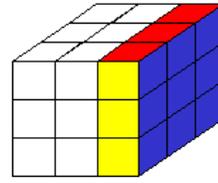
Layers or faces or slices – No matter how you hold the cube, you can identify six layers (or slices) we will use to turn and solve the puzzle. Of course, depending on how you hold the cube, say, WHITE on top and BLUE as front, the slices are formed differently. For the sake of brevity, the slices are termed as L, R, U, D, F, and B as shown below.



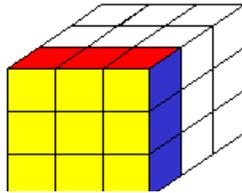
L: left Slice/Layer



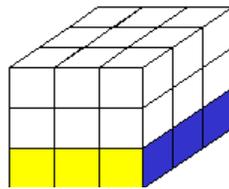
U: Upper



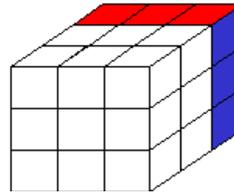
R: Right



F: Front



D: Down/Bottom



B: Back

Each of the 20 edges and corner pieces has a **CORRECT** position. These pieces all must be in the **CORRECT** position when the cube/puzzle is solved.

CORRECT POSITION – an edge and a corner piece is in *correct* position when all sides (2 for an edge and 3 for a corner) of the piece match with the cube face colors. A piece could be in its proper location, but it still isn't **CORRECT** until all its sides properly match the cube color faces.

| | | |
|--|--|---|
| <p>The corner piece (White, Red & Blue) is in correct position as all its sides match the cube face color. (White, Red, and Blue sides matches the cube faces)</p> | <p>These edges are not correct position. (White side of edge matches, but the Green side does)</p> | <p>This edge is in correct position. (Orange and Green sides match cube side colors).</p> |
| | | |

Relax!

If all these steps and instructions look too complicated, it might help to know that when you finally learn to solve the cube by following the pages of descriptions, you will only need to keep **MOVES** in the **Wallet Guide** (Last page) only. Shoot for doing the first layer intuitively or memorizing first few moves.

Phase II Cuddling the Cube

Here you learn how to move all SIX faces of the cube in both CLOCKWISE and COUNTER-CLOCKWISE directions. The direction of rotation is always determined by looking into the face. (*While turning a slice, hold the other two layers tight & fixed.*)

Exercises:

1. Identify and confirm that you know all 12 edges and 8 corners.
2. Check and confirm that the six face pieces are fixed. In other words, no matter how you turn the cube or slices, the relative position of the center pieces don't change. For example, The YELLOW is always at the bottom (opposite) when WHITE is on top.
3. Hold the cube in your hand with WHITE (or any color) on top and BLUE in front (DO NOT CHANGE THIS POSITION WHILE MAKING MOVES). Perform the following moves/rotations (a move is considered 90 degree turn):
 - a. R' – Rotate RIGHT slice counter-clockwise (Pieces come toward you)
 - b. R2 – Move RIGHT slice twice (2 x 90 degrees)
 - c. L, L', L'2
 - d. U2, U'
 - e. D'D2
 - f. F, F', F2
 - g. B, B', B2
 - h. Turn & hold the cube so that GREEN is on top. Perform (a) – (g) above with RED in front.
4. Rotate all slices in random and get used to performing rotation of any and all slices in both directions. If you started with a solved cube, perform turns and mix it up in a worst possible ways.

Test your skill:

- | | |
|--|-----------------|
| 1. Can you move a BLUE-WHITE edge to top-right corner? | []Y []N |
| 2. How many pieces have color RED on one of its sides? | []8 []12 []9 |
| 3. How many pieces have only one side? | []12 []6 []8 |
| 4. How many corner pieces have RED and BLUE | []2 []4 []3 |

Phase III Positioning the Pieces

In this exercise, you will learn to position a piece at any place desired. Make moves like $R' F$ and see what happens to the pieces. Observe how they move from place to place and how the orientation (direction of faces) changes.

Exercises: Start turning slices as you like and see if you can bring some edges and corner pieces to *correct* positions.

Simple Moves – these are moves that you perform to satisfy an objective without regards to what happens to the rest of the pieces or faces. You will generally use these for completing first layer.



(1) Rotate this RED-WHITE edge to align its sides correctly. Notice that it is in the right location, but is not oriented correctly.

U – WHITE, F – GREEN, and R -RED

Hold the cube as above and perform these moves:

$R' F D F' R^2$

Keep an eye on this piece as you perform each move. This will help you perform other moves to satisfy special objectives.



(2) Reposition this corner piece correctly such that WHITE is on top and GREEN and RED sides matches the corresponding faces.

Like in the last case, keep **GREEN face as the front**.

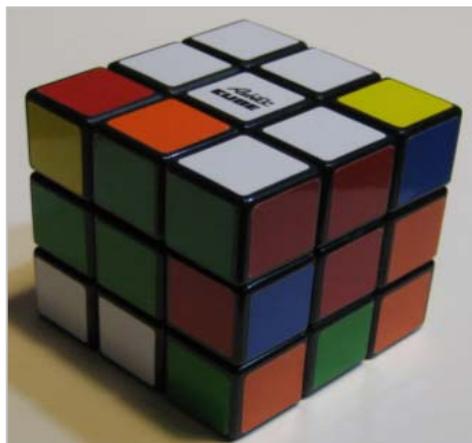
Hold the cube as above and perform these moves:

$R' F'$
Or **$R' D' R D^2 F D' F'$** (leave top edges undisturbed)

Watch as the subject cube moves. Ignore what happens to other neighboring pieces. Later on you will learn moves that will position a piece without disturbing too many other pieces.

When you perform the above moves, the subject pieces would be correctly positioned as shown here.

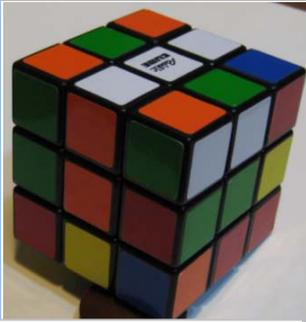
More practice ideas:
There are 4 edges with one side as WHITE. Find them and try to move them without disturbing other correctly positioned edges on the top layer.



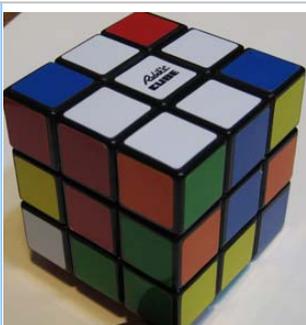
Test your skill:

How many moves do you need to shift a piece from BOTTOM-BACK-RIGHT corner to TOP-FRONT-LEFT corner?

Below are a few additional moves to build a CROSS and corner pieces in the first layer (Upper-WHITE). In these exercises, we are concerned only about subject pieces in the first layer and are not worried about what happens to the pieces in other layers.

| | | |
|---|--|---|
| Move P1: Place the White-Orange to its correct location with White face up | | (Finished photo at right) |
|  | Using WHITE as U (upper) and Orange as F (front) Move: R' F' This moves the piece to its correct position. Of course in this process, we did not care about any piece in the front face as our goal is to make the CROSS in the first layer (WHITE) |  |

| | | |
|--|---|--|
| Move P2: Rotate the White-Green piece on Top-Right edge | | (Finished photo at |
|  | Move: R' F D F' R2 This move rotates the piece without disturbing the other WHITE pieces already in place in the Top layer. |  |

| | | |
|---|--|---|
| Move P3: Move the Blue-White piece on Top-Back position | | (Finished photo at right) |
|  | The Top layer has already three of the four edges in the correct place. The purpose is to move the Blue-White piece to the top, White side facing up, without disturbing the other three edges. ← Blue-White piece (White side is in the back) Move: R' D R B2 |  |

Move P4: Exchange the positions of White-Green and Orange Green edges

(Finished photo at right)

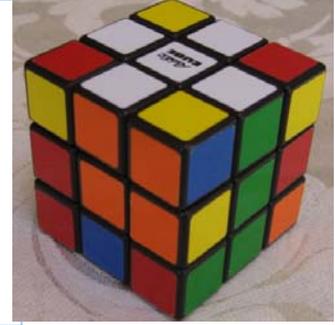


Move these two pieces without disturbing the CROSS.

Hold cube such that **Orange face is Front** (F).

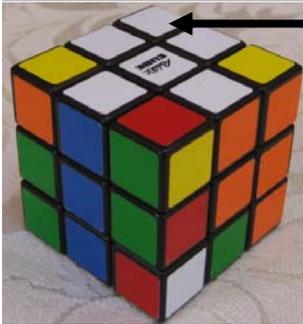
Move: **R2 D' F2 D R2**

Watch how the pieces move. You would be able to use such moves in many other situations.



Move P5: Move a corner piece from one corner to another

(Finished photo at right)



This corner piece is White-Blue-Orange

Move this corner piece without disturbing the CROSS in the first layer.

Hold cube such that **Orange face is Front** (F).

Move: **R D' L D' L' R**

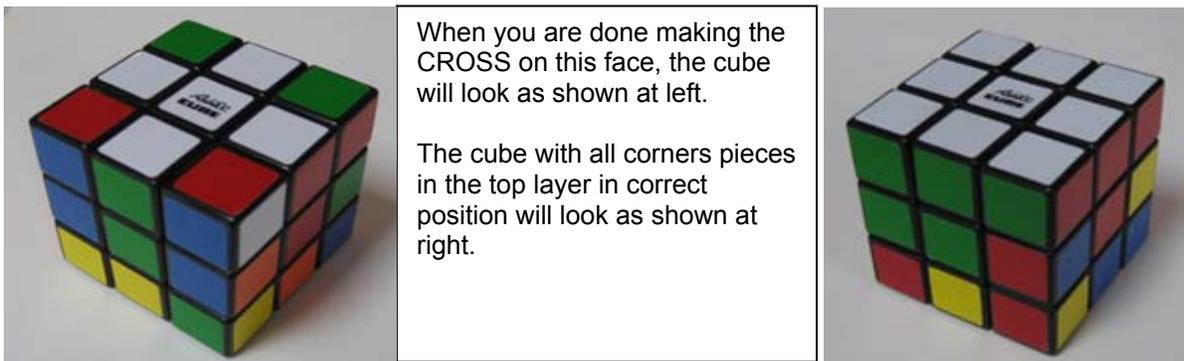


Phase IV: Fixing the First Layer

The procedure you will follow to solve the Cube puzzle require that we complete one layer at a time, first layer followed by middle layer, and then the third layer. (You will make use of one or more of the **5 standard set of moves** for corner pieces in the middle layer)

Form a cross on one of the faces (Let's use WHITE): You should do this intuitively by holding the cube in any manner you like (Keep WHITE as the upper layer). Look for edges with one side WHITE and keep turning slices to *correctly* position them. Don't give up or get frustrated. You must be comfortable doing this to tackle the next steps. Your goal is to form the WHITE CROSS without worrying about what happens to the other sides or corners. Just make sure that the 4 edges with WHITE sides also *correctly* match its other colors (Like GREEN with green side of the cube.)

Note that the 4 edges with WHITE can be in any of the 12 edge locations. It can also be in correct location, but *incorrectly* oriented. You should be able to use (1) move from Phase III above.



Complete the 4 corners of the first layer: Once you have completed the cross, you may proceed to position the four corners *correctly*. Remember, the *correct* position require that the *correct* corner is oriented *correctly*. To do so, you will use the one or more of the following 5 set of moves depending on where the correct piece is located. (Note that front-right corner is your reference edge and top-front-right corner is the subject corner.)

Understand that the *correct* corner may be located in any of the 8 possible locations. It may also be where it should be (WHITE and other two sides matched the cube face colors), but, is not oriented *correctly*. No matter where it (Target corner- TOP-FRONT-RIGHT) is located, **you will need to place it in one of the following 5 configuration first**, and then use the moves shown.

Suppose that you have completed the CROSS and chose to hold the cube such that ORANGE is front and GREEN is right. Your target corner (piece you are looking for) is WHITE-GREEN-ORANGE. The piece you have now is WHITE-BLUE-RED. Find the WHITE_GREEN_ORANGE piece you need and make the moves depending on its configuration.

Caution: While trying to bring the target corner piece to front-right edge, make sure that you DO NOT DISTURB THE CROSS you already made. If by chance you destroy the CROSS, fix it first, and then proceed.

Moves: Apply moves shown based on the five possible location of target corner piece.

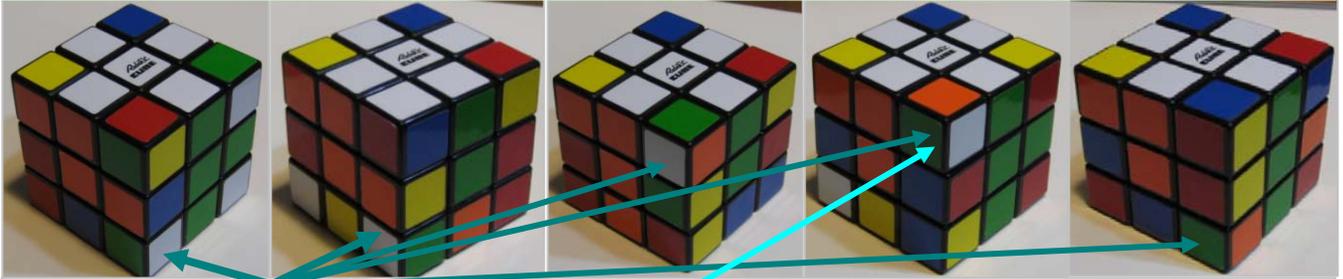
(1.1) $D F D' F'$

(1.2) $D' R' D R$

(1.3) $F D F' D^2 R' D R$

(1.4) $F'D'F D^2 F D' F'$

(1.5) $R F' R' F^2 D + F' D^2 R' D R$



Desired corner (WHITE-GREEN-ORANGE): To be moved to Top-Front-Right corner with correct orientation (WHITE on top)

Once the target corner is *correctly* positioned, turn (keeping WHITE on top) the whole cube to work on other corners following the same routine. (Use Front-Right as your reference edge)

Exercise: Practice putting together the CROSS and the corner pieces. Try the same with other color faces.

After doing these five moves several times, you should be able to memorize and/or do it intuitively. It is not necessary that you memorize it, but if you did, you will build a great deal of confidence.

Phase V: Easily Done SECOND LAYER

You will complete the second layer by *correctly* positioning four edges. (You will make use of **2 standard moves** in this phase)

With WHITE face completely done, turn the cube up side down such that **WHITE is now at the bottom** (Down face) and the **YELLOW is on top**.

Look at the four edges and see if you are lucky to have any *correctly* positioned. It's alright if none is. We will slowly place them all in their correct position.

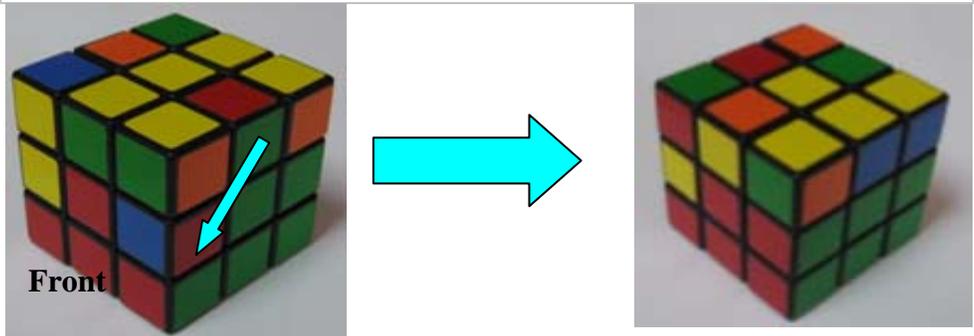
The four correct edges are all located either in the middle (layer we are working on) or the top layer YELLOW face). This is because; the bottom layer is complete and remains untouched as it has all pieces *correctly* placed.

The edges may remain in any of these configurations:

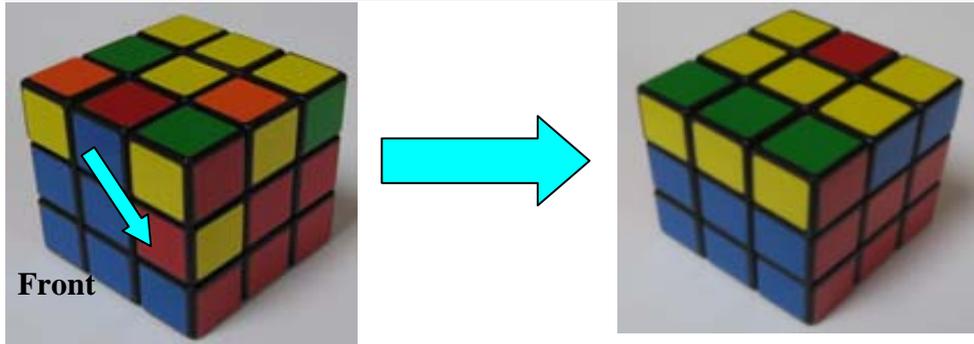
1. *Correctly* positioned in second layer (middle layer) – Nothing to do.
2. It is in top layer – Follow one of the two moves shown below.
3. It is in middle layer, but not in the correct location - Follow #2 & repeat.
4. It is correct location, but in*correctly* oriented – Follow #2 & repeat.

CAUTION: Make sure you set and hold the FRONT as front at all times during the move.

Second Layer: GREEN-RED edge moves to the location of BLUE-RED edge.
Move 2.1: **U' F' U F U R U' R'**



Secod layer: BLUE-RED edge is moved to eh location of RED-YELLOW edge. **Move 2.2:** **U R U' R' U' F' U F**



Phase VI: Challenging THIRD LAYER

Here you will make the CROSS first, and then the four corners. It gets relatively harder and the formulas are complicated as while doing it you do not want to disturb the pieces in the two layers you completed. (In this phase, you will make use of many of the **12 set of moves** shown below.)

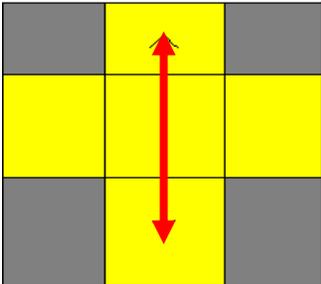
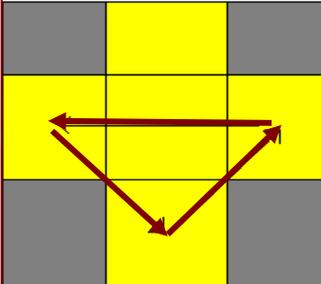
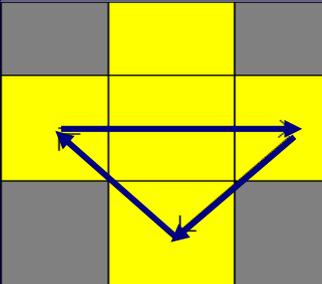
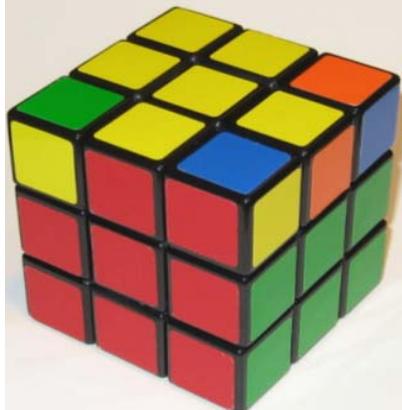
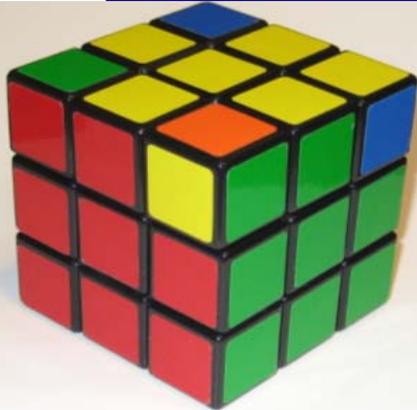
Look at the top layer (YELLOW - top) and determine which among the three configurations you have. Turn the cube so that you may match the YELLOW center and edge pieces (ignore colors of corner pieces). Once you find a match, fix your FRONT, RIGHT, etc. and keep it throughout a set of moves (**Never loose the cube orientation during a set of moves**).

Your goal is to make the CROSS regardless of whether the edges are positioned *correctly* or not. After you make the cross (as shown below, right), you will have chance to position the CROSS pieces *correctly* (so that their sides match the corresponding cube face colors)

| | | |
|--|---|--|
| | <p>(You are working on YELLOW face and interested in pieces with YELLOW side)</p> <p>← Move 3.1: F R B U2 B' U R' F' L' U2 L</p> <p>Be sure to select and hold FRONT →</p> <p>← Move 3.2: F U R U' R' F'</p> <p>Get this completed CROSS →</p> <p>← Move 3.3: F R U R' U' F'</p> <p>DO NOT PAY ATTENTION TO WHAT'S IN THE CORNERS. Just look for the YELLOW edges.</p> | |
| | | |
| | | |

Now that you have the CROSS made, they may not be correct. Look at each edge and see if their side colors match the cube face. Try rotating the top layer to see if you are lucky to have all edges *correctly* positioned (*You would alyas have ONE face/edge match correctly*). If not, which would be the case most of the time, use one of the three sets of moves below to *correctly* position the edges. Study the ARROWS in the diagram below to select your configuration and determine FRONT face.

Remember, for the CROSS to be correct, it not only have four edges with YELLOW facing up, all sides of the edges must also match the face colors of the cube (See cube on the right below).

| | | | |
|--|--|--|---|
| (3.4) R B' R' B F R' F B' R' B R F2 | ← Move → | (3.5) L U L' U L U2 L' | (3.6) R' U' R U' R' U2 |
|  | <p>Use these moves, as applicable, to move the pieces as shown. You may need to use to complete the CROSS you make in the third layer.</p> |  |  |
|  | <p>← The CROSS at left is <i>incorrectly positioned</i>. Since the YELLOW-ORANGE edge is in the wrong place, there is at least another edge is incorrectly placed.</p> <p style="text-align: right;">→</p> <p>The CROSS at <i>right is correct</i> as all edges are lined up with the corresponding face colors like the YELLOW-GREEN one.</p> |  | |

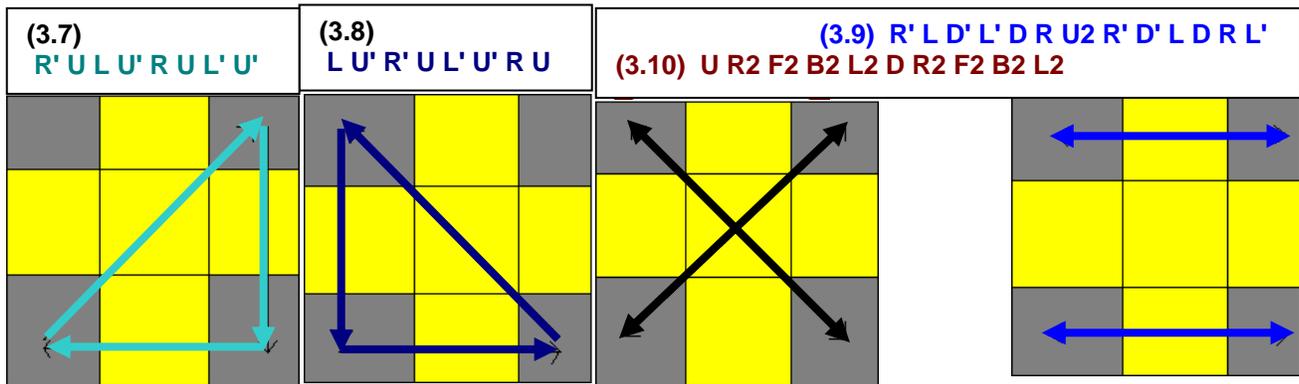
Once you have done the CROSS with all edes *correctly* positioned, you are ready to position the four corners.

Hold the cube and align the CROSS *correctly* with the faces. Now, study the four corner pieces carefully to see if any is in the correct position and orientation. The four corners may exist several possible configuraions:

- (a) The corner piece in correct location not *correctly* oriented
- (b) The piece is in correct location and in correct orientation
- (c) The piece is not in correct corner.

POSITIONING CORNER PIECES CORRECTLY:

Notice that, in the diagram at right above, the ORANGE-YELLOW-GREEN corner piece is *correctly* placed. This means that one or all remaining three pieces are also at incorrect location. So, the first thing you have to do is to bring all four corners to their correct locations no matter what orientation they place themselves. Of course, you want to do this without disturbing the CROSS in the top layer or the other two layers. To position the corners, use one or more of the four moves shown below. The end of the arrows show the direction in which the pieces move.



Note that, if you have one corner correct to start with, you will use move C1 or C2 above to position the corners. Your first goal is to position the corners *correctly* regardless of their orientation. Matching the colors of the corner pieces with the cube sides comes next.

After you have positioned all corner pieces in the proper locations, you can now proceed to orient (rotate and align faces of the pieces) them *correctly*.

ROTATING CORNER PIECES:

After you moved all corner pieces to where they belong, you may find all or two do not have correct orientation. It would be highly unlikely that you have all four corners oriented *correctly* while you are moving them to proper corners. You will learn how to rotate TWO CORNERS in two different configurations described below.

Four Corners are Incorrect - Follow moves for TWO Incorrect corners and repeat as necessary.

Two Corners are Incorrect - You will encounter one of the two configurations shown below (Configuration 1 and Configuration 2). Follow the one that applies to your case. To work on the incorrect pieces, place them on Top-Right edge. In the set of moves you perform, you are working on (as **reference**) Top-Front-Right corner piece. (You should always bring the subject piece in this location first).

CAUTION:

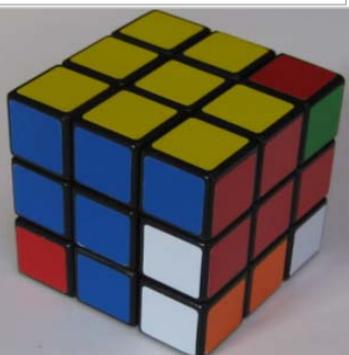
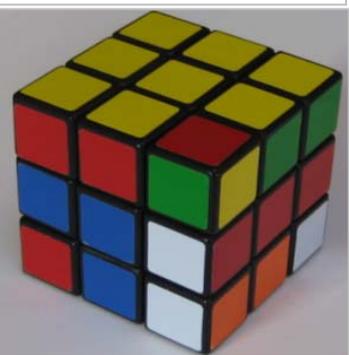
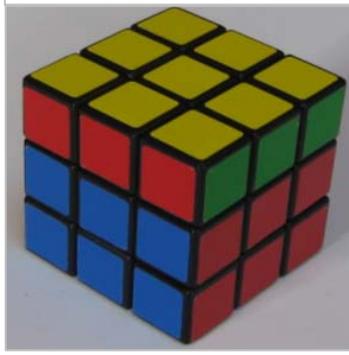
- Hold cube as shown below (your front face color may be different) and keep this orientation at all times during the move.
- Follow the steps noticing that, after Step 1, the cube may look scrambled.
- The cube shown below each Step is after the moves are performed.
- In Step 2, turn the top layer (U in this case) to position the second piece in the Top-Right-Front corner.
- Perform moves in Step 3. Now the top layer is done.
- Turn top layer (U') to align the top layer and finish the cube.

Be careful about the following two moves. They might be confusing. Each move has two parts and rotates two pieces. With respect to BLUE as your front face (and YELLOW as top), the subject piece must be in the FRONT-TOP-RIGHT corner as shown. Once the first piece is rotated, you move the second piece (Step 2) in the FRONT-TOP-RIGHT corner by rotating upper layer (as many turns as needed).

Configuration 1: Rotate YELLOW-BLUE-RED piece at Top-Front-Right corner.

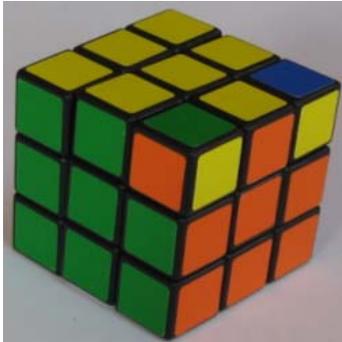
| | | |
|---|--|---|
|  | <p>← Yellow face of this corner piece is not visible.</p> <p>Hold cube as shown →</p> <p>Top/Upper face is of cube YELLOW. Front face is BLUE.</p> |  |
|---|--|---|

Move 3.11 F D2 F' R' D2 R + R' D2 R F D2 F' (See below)

| | | |
|--|---|--|
| <p>Step 1: F D2 F' R' D2 R Top-Front-Right corner piece is rotated as shown.</p> | <p>Step 2: Rotate upper layer to bring RED-GREEN-YELLOW piece to Top-Front-Right corner as shown.</p> | <p>Step 3: R' D2 R F D2 F' (Both pieces are done).</p> |
|  |  |  |

Key Observation – While working with the third layer, if at any time after you finished complete move, you find that either first or second layer is disturbed, most likely you made a wrong move. Unfortunately, in this case, you may have start from the beginning.

Configuration 2: Rotate YELLOW-RED-GREEN piece at Top-Front-Right corner.



← Blue face is not visible.

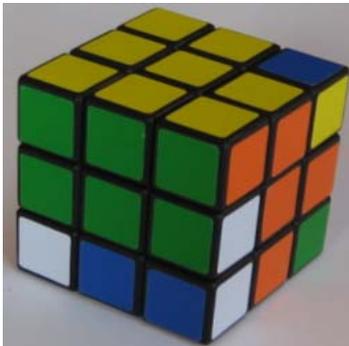
Hold cube as shown →

Top/Upper face is YELLOW.
Front face is GREEN.

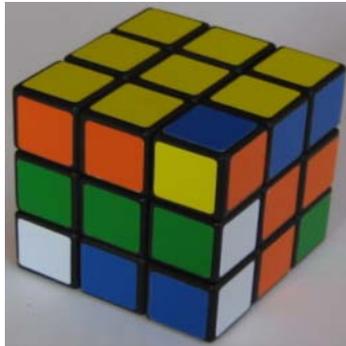


Move 3.12 $R' D2 R F D2 F'$ + $F D2 F' R' D2 R$ (See below)

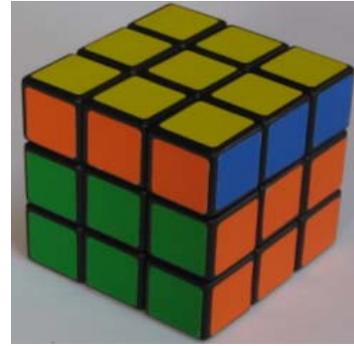
Step 1: $R' D2 R F D2 F'$
Top-Front-Right corner
piece is rotated as shown.



Step 2: Rotate upper layer to
bring BLUE-YELLOW-
ORANGE piece to Top-
Front-Right corner as shown.



Step 3: $F D2 F' R' D2 R$
(Both pieces are done).

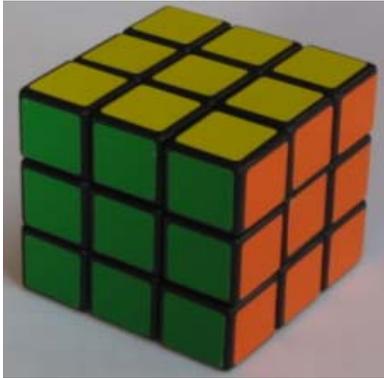


Perform above moves if you have more pieces that need rotated. Otherwise, you are done. Simply rotate the top layer to match with the cube face colors.

REMINDER: For demonstration purposes we started with WHITE as the first layer, and finished with YELLOW as the third layer. Indeed you could start with any face color you like. A good practice for you will be to follow the demonstration colors and see if you can match the results of the steps and moves.

This is how your finished cube should look.

Finished Cube: Rotate YELLOW-RED-GREEN piece at Top-Front-Right corner.



← Blue face is not visible.

Hold cube as shown →

Top/Upper face is YELLOW.
Front face is GREEN.



CONGRATULATIONS!

Last words – If things didn't happen like it should, most likely, you made a wrong move. Don't panic! Give yourself several sessions on each phase. YOU CAN SUCCEED.

ROYRK
Bloomfield Hills, MI. January 2008

SOLUTION: [Basic steps \(2 Page Version\)](#)

Notation:

L = Left Slice
 V = Vertical-Center Slice (no moves associated with this slice)
 R = Right Slice
 U = Top Slice
 H = Horizontal-Center Slice
 D = Down Slice
 F = Front Slice
 M = Middle Center Slice (no moves associated with this slice)
 B = Back Slice

Cube Components: Rubik's cube consists of 26 individual components of the following characteristics.

- 6 Center pieces one in each of the SIX colors (Blue, Red Yellow, Green, Orange and White). These pieces are fixed (do not move when you turn faces). These faces are used as references.
- 8 corner pieces. Each of these pieces has three sides of different colors.
- 12 corner pieces each of which has two different sides (colors)

Solution Strategies:
 Depending on your cube's configuration and your skill level, you may or may not all the FORMULAS given for each layer.

Step 1a: Form a cross on one of the faces (Let's use WHITE)

You should do this intuitively by holding the cube in any manner you like. If you are not familiar with Rubik's cube, practice moving faces (front, right, left, back, upper, down etc.) and form the CROSS. Your goal is to form the white cross without worrying about what happens to the other sides or corners.

Step 1b: Finish the face by placing the corner pieces (First Layer).

- Find the corner piece. The RIGHT corner piece is the one that has **WHITE** and two other colors that matches the two sides.
- Orient and position the piece by using one of the moves shown below. (The piece shown moves to bottom-right corner)

1.1

$U' F' U F$
 (Down face is white) – Moves cube on Top-Right corner to Down-Right with white face down.

1.2

$U R U' R'$

You should understand these two moves rather than trying to memorize them.

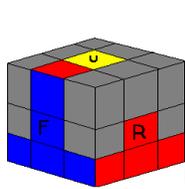
1.3

Do something like $R U' R'$ or $F' U F$ to turn this case into one of the first two. With these moves it is possible to fix all corners of this first face.

There are several approaches to solving Rubik's cube. In this approach you proceed by solving LAYER at a time; in three major phases. **Before you proceed to the next steps**, try the first step several times such that you are:

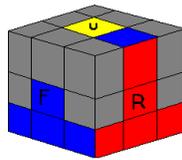
- Comfortable with move NOTATIONS
- Able to follow the diagrams and understand and able to maintain orientations (FRONT, RIGHT, etc.)
- Able to understand how corner pieces are rotated in general and complete the FIRST LAYER.

Step 2: Place four edge pieces in the SECOND LAYER.



2.1

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

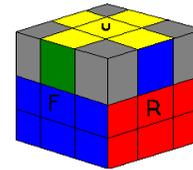


2.2

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

Note that there are **four EDGE pieces** in the second layer. These pieces may be in the **WRONG** place in second layer or on top layer. (Blue-Red piece in the top layer comes to front-right in middle layer.)

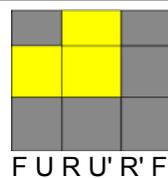
Finished SECOND LAYER



2.3

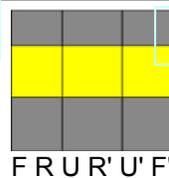
If the piece you need is in second layer but wrong place, move them first to top layer by doing one of the moves.

Step 3a: Create the CROSS in the THIRD LAYER



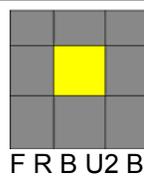
3.1

$F U R U' R' F'$



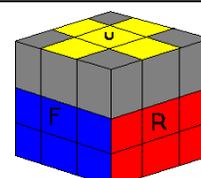
3.2

$F R U R' U' F'$

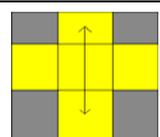


3.3

$F R B U_2 B' U R' F' L' U_2 L$

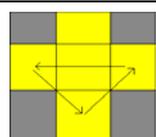


3.4



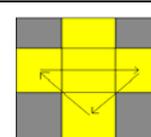
3.5

$R B' R' B F R' F B' R' B R F_2$



3.6

$L U L' U L U_2 L'$

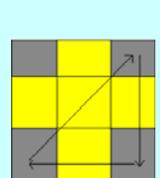


3.7

$R' U' R U' R' U_2 R$

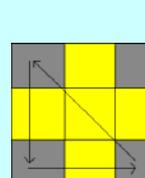
Once the cross is formed, check to make sure that the side colors matches the face colors.

Step 3b: Place the corner pieces in the THIRD LAYER



3.8

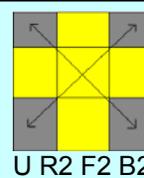
$R' U L U' R U L' U'$



3.9

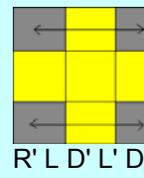
$L U' R' U L' U' R U$

With matching cross, you can proceed to position the corner pieces in the top (Third) layer by one of these moves.



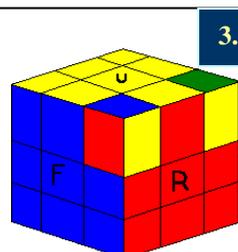
3.10

$U R_2 F_2 B_2 L_2 D R_2 F_2 B_2 L_2$



3.11

$R' L D' L' D R U_2 R' D' L D R L'$



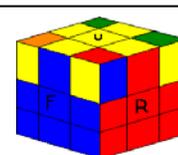
3.12

Two corners are wrong

Put the corner piece in the top-front-right position.
(Both moves needed for completing process)

- $R' D_2 R F D_2 F'$. (CC for yellow to move on top)
- $F D_2 F' R' D_2 R$ (C-clockwise)

Then **move U** until the other corner is in the top-front-right position; **Move U** (only). Now, continue moves in the **opposite direction than that for** the first corner.



3.12

Four corners are wrong

Do the same as for two corners.

POCKET REFERENCE

2nd Layer –Edges: **U' F' U F U R U' R'** and **U R U' R' U' F' U F**

3rd Layer – CROSS

_I: **F U R U' R' F'**

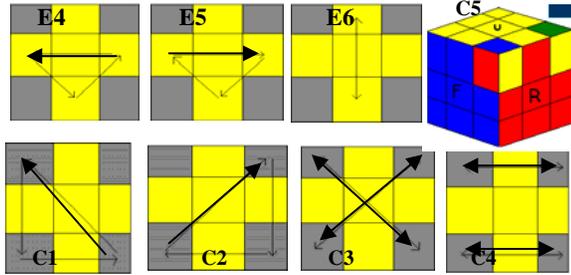
---: **F R U R' U' F'**

= : **F R B U2 B' U R' F' L' U2 L**

E4: **L U L' U L U2 L'**

E5: **R' U' R U' R' U2 R**

E6: **R B' R' B F R' F B' R' B R F2**



3rd Layer- CORNER

C1: **L U' R' U L' U' R U**

C2: **R' U L U' R U L' U'**

C3: **U R2 F2 B2 L2 D R2 F2 B2 L2**

C4: **R' L D' L' D R U2 R' D' L D R L'**

C5: **R' D2 R F D2 F' + F D2 F' R' D2 R**

References:

Simulation site: <http://howtosolvearubikscube.weebly.com/>