

## RUBIK'S 4th DIMENSION CUBE

If you have a Rubik's 4th Dimension Cube you will need to learn how to correctly align the symbols which are found on four of the six faces. If you have solved the colors on all of the faces first then you will need to learn several more complex series of face turns in order to rotate the four symbols so that all are upright.

But that would be a waste of time and effort for, if you align the symbols first, the process is simplicity itself provided you use the method given on these pages to solve the cube. The cube must be held so that the symbols are on the vertical faces while placing edge pieces but orientation is immaterial while placing corner pieces. If a vertical face is rotated in a given direction early in an Edge Piece Series then it is rotated in the opposite direction later. At the conclusion of every series the four symbols will each have the same alignment as they did in the beginning. Therefore, if you properly align all four symbols before you begin to apply The Ultimate Solution then the symbols will be properly aligned when you have completed the solution.

Hold the cube so that either the orange or the red face is on the top (that is, either of the faces without one of the symbols on it). Put three of the top edge pieces in place relative to each other. Make sure that the fourth top edge piece is on the bottom of the cube with its top face color on the bottom face of the cube.

The position where the fourth top edge piece belongs is above one of the four vertical face symbols. It makes no difference which one. The fourth top edge piece must not be below this symbol. If necessary, rotate the bottom face so that this fourth edge piece is in one of the other positions. Now rotate the vertical face (if necessary) so that the symbol is upright.

Rotate the top face  $90^\circ$  and repeat this process for the second symbol. Again rotate the top face  $90^\circ$  and carry out this process for the third symbol.

Rotate the top face one more time and the fourth symbol will be below the slot where the fourth top edge piece belongs. This time rotate the vertical face so that the symbol is upside down. Now rotate the bottom face so that the fourth top edge piece is below the last symbol. Rotate this vertical face by  $180^\circ$ . The fourth symbol is properly aligned (upright) and the fourth top edge piece is in place relative to the other three. Rotate the top face until the top edge pieces are properly aligned with the vertical face colors.

All four symbols are properly aligned as are the top edge pieces. Complete the remaining steps of The Ultimate Solution and the Rubik's 4th Dimension Cube will be restored to its original condition. Now wasn't that easy?

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# THE ULTIMATE SOLUTION TO RUBIK'S CUBE

**A unique solution using only two series**

**Requires only 65 moves to solve a scrambled Rubik's Cube**

**This site also contains solutions to**

**2x2x2 cubes**

**3x3x3 cubes with images**

**4x4x4 cubes**

**5x5x5 cubes**

**dodecahedron**

## **The Ultimate Solution to Rubik's Cube**

**[The Edge Piece Series](#)**

**[The Corner Piece Series](#)**

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If you have mastered The Ultimate Solution to Rubik's Cube and also solved scrambled versions of the other cubes given above, then perhaps you are ready for a still more challenging puzzle. In theory one can design a true four dimensional analog of Rubik's Cube (3x3x3x3). While one cannot make a working model of this puzzle in the real world, one can project its image into three dimensions which can then be displayed, manipulated and solved using standard 3D computer graphics. You can find [MAGIC CUBE 4D](#) on the web. It was designed and constructed over a period of several years by Daniel Green and Don Hatch with later help from E. Jay Birkenbilt.

Check it out!

Latest revision: 4-6-2005

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## THE EDGE PIECE SERIES

In this approach to solving a scrambled Rubik's Cube all 12 edge pieces are placed first. The first four are placed in Step One which is straightforward. Some of the others are moved into place with a simple replacement process. The remainder utilize a symmetric four turn series which moves three edge pieces around a corner of the cube.

The red face of the cube in Fig. 1a is front. The red/yellow edge piece at front/top belongs at front/right. We cannot simply rotate the front face clockwise by  $90^\circ$  because we have already placed four blue edge pieces on the bottom face and would not want to move any one of them out of place. But an Edge Piece Series will move the red/yellow, orange/yellow and red/green edge pieces around the front/right/top corner of the cube without moving other edge pieces. (These edge pieces have been numbered #1, #2 and #3.) According to standard notation this series is F R' F' R.

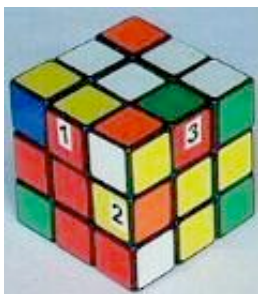


Fig. 1a

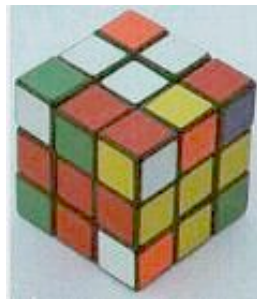


Fig. 1b

Applying this series gives the cube shown in Fig. 1b. We find that edge piece #1 is now in the position originally occupied by edge piece #2. That is, #1 replaced #2. Further, #2 replaced #3 and #3 replaced #1. The three pieces moved about the front/top/right corner of the cube in a counterclockwise direction. The blue edge pieces on the bottom of the cube are undisturbed. Some corner pieces have also moved but that is immaterial. At this time we are interested only in the movement of edge pieces.

We can also describe this series in terms of the movement of edge pieces #1, #2 and #3.

Turn one	Front clockwise	#1 replaces #2
Turn two	Right counterclockwise	#3 replaces #1
Turn three	Front counterclockwise	reverse turn one
Turn four	Right clockwise	reverse turn two

Now let us consider what has happened to these edge pieces. If the front face in Fig. 1b is turned  $90^\circ$  counterclockwise we find that edge piece #1 (red/yellow) has the same

orientation as before. The same is true of edge piece #2 (turn the right face  $90^\circ$  counterclockwise). But edge piece #3 is different. If we turn the top face  $90^\circ$  counterclockwise we find that edge piece #3 has been inverted.

This is always true of these edge pieces. Edge pieces #1 and #2 are not inverted while edge piece #3 is inverted. You are free to number the three edge pieces in any way you want to. Then, provided you always follow the turn sequence given above, you will find that #1 replaces #2, #2 replaces #3 and #3 replaces #1. Edge pieces #1 and #2 will not invert while #3 inverts.

Look at the cube in Fig. 2a. This is the same cube as in Fig 1a except that the top face has been turned  $90^\circ$  in a counterclockwise direction. We still want the red/yellow edge piece to move into the front/right position. But to be properly placed it must invert. Hence it must be edge piece #3. Since #3 replaces #1 then orange/yellow must be edge piece #1. Green/white then is edge piece #2.



Fig. 2a

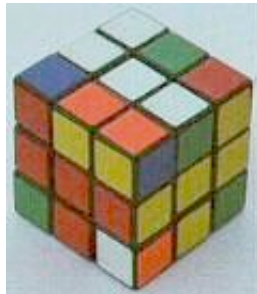


Fig. 2b

We will apply the series as before.

turn one	#1 replaces #2
turn two	#3 replaces #1
turn three	reverse turn one
turn four	reverse turn two

Now examine the result, the cube in Fig. 2b. Again we have accomplished our main purpose, the movement of the red/yellow edge piece into its proper position and orientation at front/right. The orange/yellow piece is involved in both instances but it moves to a different location. However, red/green is involved in the first case while the green/white piece has replaced it in the second series. In the second example, the three pieces have moved in a clockwise direction about the front/right/top corner of the cube.

The red/yellow edge piece may be moved into its correct position/orientation from a position above either the red or the yellow center pieces by an Edge Piece Series. Which version of the series you will want to use will depend on what else you are trying to accomplish. We will visit this situation again in Step Two of the Ultimate

## **Solution to Rubik's Cube.**

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## THE CORNER PIECE SERIES

The corner pieces are put into proper position/orientation following the placement of the 12 edge pieces. After the edge pieces are placed we will find some corner pieces may already be correctly placed while some are properly positioned but not properly oriented. The remainder will be in the wrong position. The incorrectly placed corner pieces will be moved into proper position/orientation using the Corner Piece Series.

The Corner Piece Series has eight 90° turns and is perfectly symmetrical. The first turn is always a turn of the top face. Such a turn is indicated by a curved arrow on the top face of the cube with the point of the arrow ending on the back part of this face. The first figure in the set of eight below indicates that the top face is rotated clockwise. We will say that this face is turned to the right because the arrow at the back of the top face points to the right. This is simply a convention but it will enable you to more easily recall this series. The symbols below indicate the eight turns in one example of the series. You are looking down on the top face of the cube.



The first move of the top face may be either to the right or to the left, but the rules governing the succeeding moves are the same in either case. The second symbol shows that the top surface of the right face moves away from you.

1. The first move is a turn of the top face, either to the right or to the left.
2. The second move is a turn of the side face toward which the top was turned. It is turned away from you.
3. The top is then turned in the direction opposite to the first turn.
4. The side toward which the top was just turned is then turned away from you.
5. The top is then turned in the same direction as the first turn.
6. The side toward which the top was just turned is then turned back toward you.
7. The top is turned in the opposite direction.
8. The side toward which the top was just turned is turned back toward you.

The top is turned every other turn, alternating directions. Each side face is first turned away and then back toward you. Note that each of the initial turns is later reversed.

This series will cause three corner pieces on the top face of the cube to move about a triangle. If the first turn of the top face is to the right then the corner pieces will move

in a counterclockwise direction about the triangle. If the first turn is to the left then three pieces (two are the same but one is different) will move in a clockwise direction about a triangle which is a mirror image of the first triangle.

Let us apply a Corner Piece Series (with the first move being a turn of the top face to the right) to the cube in Fig. 3a. In this case the orange face is the front of the cube. The result is the cube in Fig. 3b. We can see that the left/front/top, the left/back/top and the right/back/top pieces have been moved. We get another view of the changes by rotating the cube 180° giving us Fig. 3c.



Fig. 3a



Fig. 3b



Fig. 3c

The red/green/white corner piece moved along the red/white edge and into the red/yellow/white corner. In the process it "rolled over" so that the white face is now on the side of the cube and in the yellow face. The red/yellow/white corner piece moved along the yellow/white edge and also "rolled over". The yellow/orange/white piece moved across the diagonal of the top face. In the process it's yellow face, which had been on the left (yellow) side, came to the top.

Note that the two corner pieces on the back of the top face and the corner piece at left/top/front are involved in this triangle. The pieces moved counterclockwise. All three "rolled over".

If the first turn of the top face had been to the left the two pieces at the rear would still be involved but the third piece would be the one in the front/right/top corner. This piece would move across the diagonal to the left/back/top corner. The pieces would move in a clockwise direction about the triangle.

Obviously the two pieces at the back of the top face are always involved along with one of the pieces at the front. How can you tell which one? You should note that the first turn immediately moves the front corner piece involved to the back of the top face. It is this piece which will eventually move across the diagonal of the top face.

If the three out-of-position corner pieces were to move in the opposite direction about the same triangle they would move back into position/orientation. These three pieces illustrate what you will be looking for as you try to solve a scrambled cube.

The red/white/green piece may be made to move along the red/white edge of the cube. As it does so it will roll over into its proper position/orientation. The yellow/white/red corner piece will do the same thing as it moves along the yellow/white edge of the



**cube.**



**Fig. 3d**

The cube has been turned another  $90^\circ$  in Fig. 3d. Now you see an example of a corner piece which can be moved across the face diagonal to its proper position and orientation. For this corner piece, the color of the top face (white) is on the right side. The orange and yellow colors do not match any side which is visible. But you should know that orange is opposite red and that yellow is opposite green. Hence this corner piece has the colors of the opposite corner.

The Corner Piece Series which begins with a turn of the top face to the left will move the orange/white/yellow corner piece across the diagonal with the white face coming to the top. The other two pieces move along cube edges and roll over into their proper position and orientation. The cube is again complete.

Of course you will not often find three corner pieces arranged so that all move into correct position/orientation in a single series. Most of the time you will find one which can move into place along a cube edge. Less often it will be a corner piece which can move across a face diagonal and into its proper position and orientation. At times there will be two pieces which can be moved into place in a single series and rarely three. But if you should find three in such an arrangement you certainly would want to take advantage of that fact.

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## STEP ONE: THE CROSS

This solution to Rubik's Cube begins, as many solutions do, with the formation of a cross on one face of the cube. You can choose any color but it is best to choose a face which already has an edge piece matching the center color of that face. The scrambled cube shown in Fig. 4a has three faces for which this is true. I have chosen the blue face but any one of the three could have been chosen. (On my cube, red is opposite orange, yellow is opposite green and white is opposite blue.)



Fig. 4a

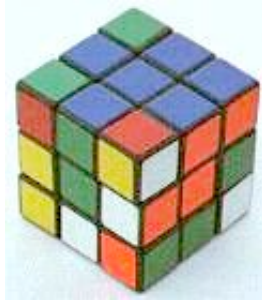


Fig. 4b

Naturally it would be better if two edge pieces had their blue color on top but only if these two pieces are in the proper position relative to each other. More often than not this is not true and one edge piece would have to be changed. In two trials out of three, two will not be better than one.

What is the best way to transform the cube to the one in Fig. 4b? Many solutions would tell you to begin by turning the top (blue) face one turn ( $90^\circ$ ) clockwise. The blue/green piece would move into its proper place on the cube. These solutions emphasize the bottom face. Target edge pieces are taken to the bottom of the cube, the bottom is turned and the target piece brought to the top in proper position and orientation. That approach would require eight moves to form the cross on the blue face of this cube.

But it is better to emphasize the top face. Edge pieces are moved to the top face so as to be in the proper relationship to top edge piece(s) already on the top face. First, examine the cube. The blue/green edge piece is already on the top face; the blue/red piece is at front/right; the blue/yellow piece is at bottom/front; and the blue/orange piece is at back/bottom.

The blue/yellow piece must be opposite the blue/green piece. In addition, the blue/red piece belongs where the green/orange piece is now. If the blue face is rotated  $90^\circ$  counterclockwise then a  $90^\circ$  clockwise rotation of the orange face will move the blue/red edge piece into place relative to the blue/green piece and a  $180^\circ$  rotation of the green face moves the blue/yellow piece into place, also relative to the blue/green piece.

Three edge pieces are in place on the blue face. We can now rotate the blue face by

180° and then the yellow face by 90° clockwise. Unfortunately this moves the blue/yellow edge piece out of position. After the blue/orange piece is moved into position/orientation by a 90° counterclockwise rotation of the orange face, the blue/yellow edge piece is moved back into place by a 90° counterclockwise rotation of the yellow face. This approach required seven moves.

But it is still better to anticipate. The first move should have been a 90° counterclockwise rotation of the yellow face. This moves the blue/orange edge piece into position so that, following placement of the blue/red and blue/yellow edge pieces, a clockwise rotation of the red face moves the blue/orange piece into its proper position/orientation relative to the other three. Finally, a 180° rotation of the blue face moves all blue edge pieces into place. This approach requires six moves. In standard notation the moves are (back is B):

**B' T' R F<sup>2</sup> L T<sup>2</sup>**

In actual practice, of course, how you proceed to form the cross is up to you. Just make sure that you can do it somehow. With sufficient practice you should be able to reduce the average number of moves required to about seven.

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## STEP TWO: CENTER SECTION EDGE PIECES

In Step Two of The Ultimate Solution to Rubik's Cube you will have two objectives which are to be met simultaneously. You will use the Edge Piece Series to move a central section edge piece from the top face into its proper position and orientation in the center section. You will repeat this process until three of the center section edge pieces are in place.

As you carry out this process some of the pieces you will be moving will be top section edge pieces. Make sure you carry out the Edge Piece Series so that, if possible, the top edge pieces wind up with their top color on the top face of the cube. This step is complete when:

- a. three edge pieces are in place in the center section,
- b. three top edge pieces have their top color on the top face of the cube,
- c. one top edge piece is in the center section and
- d. the fourth center section edge piece is in the top section of the cube.

In the beginning it is possible that one or more center section edge pieces are already in place. Fine. But it is also possible that one or more are in the proper position but with the wrong orientation. Tough. You will have to remove it (them), also with an Edge Piece Series.

Remember that a center section edge piece may be moved into proper position and orientation with that edge piece starting above either of the faces with one of the edge piece colors. The orange/green edge piece in Fig. 5a (at top/right) could be moved into place at front/right if it is treated as Edge Piece #1. But this would be a bad idea because the white/red edge piece would be inverted in the process and we would have reduced the number of top edge pieces with their top color on top of the cube from one to none.

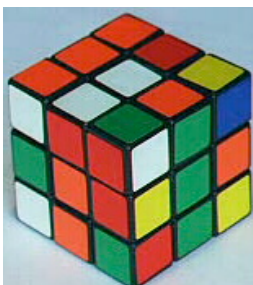


Fig. 5a



Fig. 5b

On the other hand we could treat the orange/green edge piece as Edge Piece #2 in Fig. 5a (red/white would be #1) or rotate the top face 90° clockwise (giving Fig. 5b) and treat orange/green as Edge Piece #3. The red/yellow edge piece would be #1. In either

case the orange/green edge piece moves into the proper position and orientation and the red/white edge piece will continue to have its white color on the top face of the cube.

But we need to get more white edge piece faces on the top face of the cube. In Fig. 5c the red/green edge piece belongs at front/right. If we treat the red/green edge piece as #1 an Edge Piece Series will cause the orange/white edge piece to come to the top of the cube with its orange face on top, not white. On the other hand if we treat the yellow/red edge piece as #1 then red/green is #2 and orange/white would be #3. Orange/white would come to the top of the cube with its white face on top (since edge piece #3 always inverts).

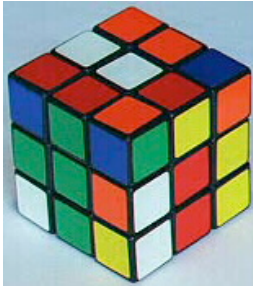


Fig. 5c



Fig. 5d

Or we could rotate the top face 90° counterclockwise (giving Fig. 5d) and apply an Edge Piece Series with the red/green edge piece as #3. The orange/white edge piece will be #1 and the red/white edge piece will be #2. The orange/white edge piece will come to the top of the cube with its white face on top and the white face of the red/white edge piece will remain on top. We will now have two white faces on the top face of the cube.

Continue this process until three center section edge pieces are in place, three top edge pieces have their top color on top and the fourth top edge piece is in the center section. The fourth center section edge piece will be on the top of the cube.

If you should, by chance, properly place three center section edge pieces but have only two top edge pieces with their top colors on top, then apply one more Edge Piece Series in which all of the pieces involved are top edge pieces. The top edge piece in the center section comes to the top with its top color on top and the top edge piece which does not have its top color on top moves into the center section.

You should note that you do not always have to complete the fourth turn of the Edge Piece Series. Whenever the fourth turn is a turn of the top face it does not need to be made because a turn of the top face can have no effect on the bottom face. Remember, the Edge Piece Series was devised not only to put center section edge pieces into proper position/orientation but also to prevent the movement of edge pieces on the bottom face.

## STEP THREE: THE TOP EDGE PIECES

In this section we will place the fourth center section edge piece and the four top edge pieces in their proper positions and orientation.

At the conclusion of Step Two, three top edge pieces were to have their top color on the top face of the cube. Those three edge pieces could be in any one of the following possible arrangements:

1. All three could be out of order.
2. Two adjacent pieces could be in the proper order relative to each other with the third out of order.
3. Two opposite pieces could be in the proper order relative to each other with the third out of order.
4. All three could be in the correct order relative to each other.

The three white edge pieces on the top of the cube in Fig. 6a are all out of order. Note that the top edge piece face you cannot see on the back of the cube must be red. If the top face of the cube is turned 90° clockwise then the yellow face of white/yellow would be adjacent to the yellow face center and white/yellow would be in the proper position/orientation.



Fig. 6a

But neither of the other two white edge pieces would be in the correct position. The green color would be above the red face center and the red color would be above the orange face center. No matter which of the three top edge pieces is put into place the other two will be out of place.

We can correct this by applying an Edge Piece Series to the cube. However, the series must involve three top (white) edge pieces. Rotate the top face until three white edge pieces are adjacent to the top/front/right corner as they are in Fig. 6a. The cube obtained by rotating the top face 90° clockwise would also be suitable.

Always be sure that three white pieces are in the series and that it concludes with three white faces on top of the cube. In all cases the white edge piece in the center

section will be edge piece #1. In Fig. 6a white/orange will be #1 and white/yellow will be #2. Any other choice would not leave three white edge pieces with their white faces on top of the cube at the end of the series. This series will change the top edge pieces to one of the other arrangements.

In the case of the cube in Fig. 6a the series converts it to the cube in Fig. 6b. Here two adjacent edge pieces are in the proper order (white/yellow and white/orange) and one is out of order (white/red where red is above green). These pieces may be put in the proper order by turning the top face by  $180^\circ$  and applying an Edge Piece Series to the top edge piece in the center section (white/green), the top edge piece which is out of order on the top face (the white/red piece) and the fourth center section edge piece (yellow/orange). The latter is moved into proper position/orientation and all four top edge pieces will be in their proper order. A  $90^\circ$  counterclockwise turn of the top face will put all top edge pieces in their proper place. Step Three is complete.

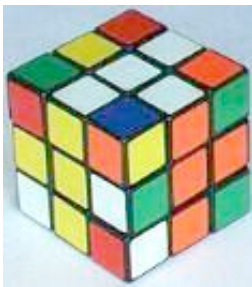


Fig. 6b



Fig. 6c

In the third case two opposite edge pieces are in position relative to each other and the third is out of place as shown in Fig. 6c. The white/yellow top edge piece is in place. By the process of elimination the color you cannot see on the white edge piece is green. Since the green face on my cube is opposite the yellow face the white/green piece must also be in its proper place. But the white/red piece is out of place. It belongs on the other side of the top face.

The white/orange piece belongs where the white/red is now. The former can be put there by a simple  $90^\circ$  rotation (clockwise) of the orange face. Turn the top face by  $180^\circ$  and a  $90^\circ$  counterclockwise turn of the orange face will move the white/red edge piece back to the top face and into its proper position relative to the other three. Finally another  $180^\circ$  turn of the top face moves all white edge pieces into place. Step Three is complete.

In the fourth case all three top edge pieces on the top face are in their proper position relative to each other. This is shown in Fig. 6d. The unseen color of the white edge piece is red and it clearly is in the red face of the cube. This arrangement is converted to one in which all four white edge pieces are in the proper order on the top face by a series of replacements.



Fig. 6d

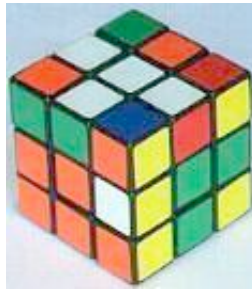


Fig. 6e

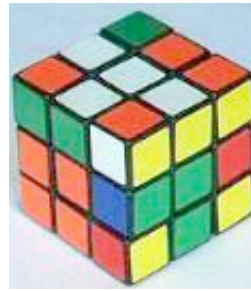


Fig. 6f

We begin by replacing a white edge piece on either end of the three on the top face with the white edge piece in the center section. For example, rotate the top face in Fig. 6d by  $90^\circ$  clockwise giving Fig. 6e. Rotate the green face  $90^\circ$  clockwise giving Fig. 6f. The white/red piece is replaced by the white/yellow piece and the former moves to the center section.

Now turn the top face  $90^\circ$  counterclockwise (Fig. 6g) and replace the white/green piece with the white/red piece (i.e. rotate the green face by  $90^\circ$  counterclockwise) to give the cube shown in Fig. 6h. Continue in this fashion until, in the fourth turn of the green face the last white edge piece (in this case the white/orange piece) returns to the top face of the cube and the fourth center section edge piece moves into place at front/right.



Fig. 6g

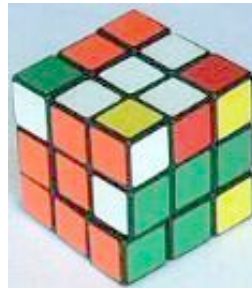


Fig. 6h

You might ask how one knows that the fourth center section edge piece has the proper orientation and is not inverted. While you made sure that the top edge pieces had their white color on top you did nothing to ensure that the center section edge piece had the proper orientation. This is true for each of these examples. But you don't need to worry about the 12th edge piece. If 11 edge pieces are in the proper position and orientation then the 12th must be in the proper position and have the proper orientation as well. It cannot be otherwise.

Turn the top face so that all top edge pieces are in position (in this case  $90^\circ$  clockwise). Step Three is complete and all edge pieces have been properly positioned/oriented.

**Go to [Step Four: Five Corner Pieces](#)**



## STEP FOUR: FIVE CORNER PIECES

Once the edge pieces have been correctly placed you will look for corner pieces which can be moved into position/orientation by a Corner Piece Series. In the discussion of that series we learned that one or more corner pieces will, almost inevitably, be situated so that this series will move that corner piece along a cube edge and into position/orientation. Others will be in a position, such that the series will move them across a face diagonal and into the correct position and orientation.

Figure 7a shows the first kind of corner piece in the front/top/right corner of the cube. The proper series will move the green/red/white corner piece along the green/red edge of the cube and into its correct position and orientation at the back/top/right corner of the cube. (That is, in the green/red/white corner.) In orienting these cubes we will always use the same convention. We will always show the front, right and top of the cube. In this case that means blue is the front, red is the right side and green is the top.

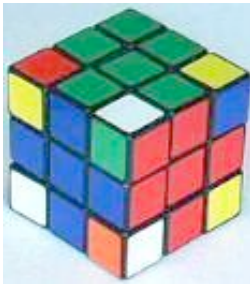


Fig. 7a

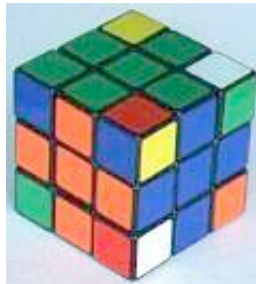


Fig. 7b

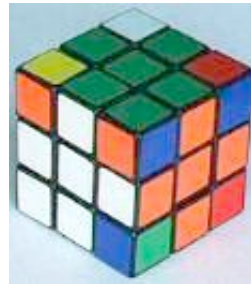


Fig. 7c

If the entire cube is turned  $90^\circ$  counterclockwise we obtain the cube in Fig. 7b. Now orange is front and blue is right. A standard Corner Piece Series which begins with a turn of the top face to the right will move our target corner piece to the back/top/left corner. It will be correctly placed in the green/red/white corner of the cube.

Turning the cube another  $90^\circ$  counterclockwise gives the cube in Fig. 7c. The Corner Piece Series is the same (it begins with a turn of the top face to the right) but the target corner piece now moves along the left/top edge rather than the back/top edge. You can use either orientation of the cube and still move the green/red/white corner piece into place. The difference is that the blue/green/orange corner piece is involved in moving about the first triangle and the blue/red/yellow corner piece has replaced it in the second case.

The red/yellow/blue corner piece is at front/top/right in Fig. 7d. This corner piece belongs somewhere on the top face because of its blue color. But the red and yellow colors do not match the other two sides (front and right) which we can see. Yellow is opposite green and red is opposite orange so this red/yellow/blue corner piece belongs in the back/top/left corner of the cube.

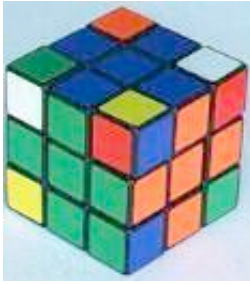


Fig. 7d

**A Corner Piece Series which begins with a turn of the top face to the left will cause the red/yellow/blue piece to move across the diagonal of the top face and into place in the back/top/left corner. In this case there is only one way this can happen.**

**If possible, one would like to place two corner pieces at the same time. You may find, by chance, that a piece goes along an edge while another goes across the face diagonal at the same time. Or perhaps two may move along adjacent cube edges. But most of the time you will have to arrange for these things to happen.**

**While other solutions will use a relatively large number of series in solving a scrambled cube this method is able to solve a cube while using only two series because of the use of preliminary face turns which change the corner pieces involved in a Corner Piece Series.**

**Turning the orange face in Fig. 7c by 180° gives Fig. 7e. We apply the same Corner Piece Series as before (start with a turn of the top face to the right) but the blue/red/green piece has become a part of the triangle. This is the piece which belongs at back/top/left and it is not only moved to the correct position it is also properly oriented. Two corner pieces have moved into place at the same time. Following this series the orange face is again turned 180° returning it to its original position.**



Fig. 7e

**The problem with this approach is that you will have to search for the new piece without any clue as to where it will be found. Rather than trying to find the piece which will replace your target piece, it is better to work with the piece which the target piece is going to replace. This is true because a glance at the latter piece will immediately tell you where it must go.**

**The target piece in Fig. 7c will replace the orange/yellow/blue corner piece at front/top/left. The Corner Piece Series (first turn is to the right) will move this piece**

across the diagonal with its blue face coming to the top. But where does the orange/yellow/blue corner piece belong? Since none of its colors match any of the faces it touches it must belong in the opposite corner of the cube. And more specifically its blue color must be in the blue face of the cube.

The front of the cube is white so the back is blue. Turn the orange face (in Fig. 7c) 90° counterclockwise and you get Fig. 7f. Apply the Corner Piece Series and the blue color of the orange/blue/yellow corner piece moves next to the blue color of the blue/orange edge piece. Turn the orange face 90° clockwise and two corner pieces have been moved into place.

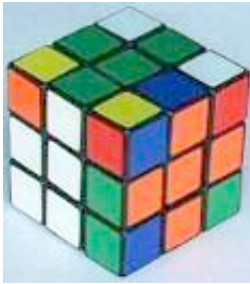


Fig. 7f

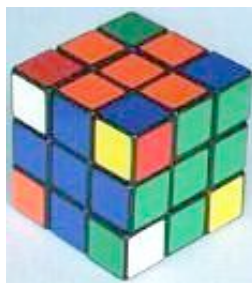


Fig. 8a



Fig. 8b

Fig. 8a shows another example. The orange/blue/green corner piece at back/top/right will move along the top/right edge of the cube and "roll over" into proper position/orientation in the front/top/right corner of the cube. It replaces the yellow/blue/red corner piece. What needs to be done to cause the latter piece to move into position/orientation at the same time?

According to its colors the yellow/blue/red piece belongs in the corner diagonally across the blue face of the cube. Rotate the yellow (left) face of the cube 180° giving Fig. 8b. Apply the Corner Piece Series (first turn of the top face is to the left) and the yellow/blue/red piece moves into place with its red color next to the red edge piece color on the left side of the top face. A second 180° turn of the left face and two corner pieces have moved into place during the same sequence of moves.

Fig. 9a shows a potential problem. A Corner Piece Series (first turn of the top face is to the left) moves the red/yellow/blue piece across the blue (top) face of the cube to its correct position and orientation. But it would also move the yellow/blue/orange out of place. To avoid this, turn the orange face 90° clockwise (giving the cube in Fig. 9b) and apply a Corner Piece Series which begins with a turn of the top face to the right. Reverse the preliminary turn of the orange face. The red/yellow/blue piece winds up in the correct place but the yellow/blue/orange piece is not disturbed.

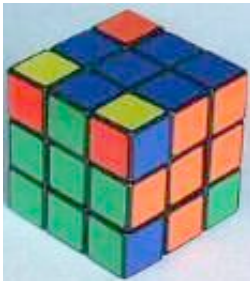


Fig. 9a

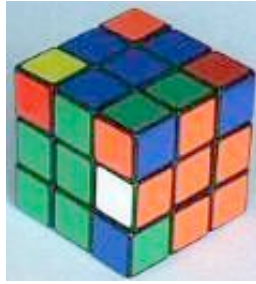


Fig. 9b



Fig. 10a

We could move three corner pieces on the top face of the cube in Fig. 10a about the triangle: front/top/right; back/top/left; back/top/right. The yellow/orange/white piece at back/top/right moves along the top/right edge and rolls over into place at front/top/right. The blue color of orange/green/blue comes to the top in the back/top/left corner. This piece belongs in the front/bottom/left corner. The blue color of the orange/green/blue piece obviously must go in the blue (left) face of the cube. It must replace the red color of the piece which is now there.

Turn the bottom face  $90^\circ$  counterclockwise and then turn the left face  $90^\circ$  clockwise. This gives the cube in Fig. 10b. A Corner Piece Series which begins with a turn of the top face to the left causes the blue color of the orange/green/blue piece to replace the red color we see in the back/top/left corner of the cube. Then reverse the two preliminary turns (left face  $90^\circ$  counterclockwise, bottom face  $90^\circ$  clockwise). Again we have placed two corner pieces during the same sequence.

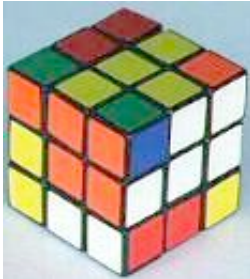


Fig. 10b

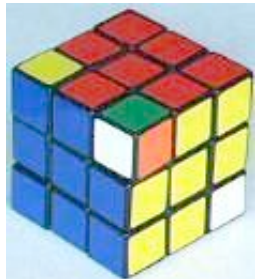


Fig. 11

The blue/yellow/red corner piece at front/top/left in Fig. 11 could move along the front/top edge and roll over into place at front/top/right. But we do not have a triangle of three out-of-place corner pieces on the top face. No problem. Rotate the white face  $90^\circ$  clockwise and the out-of-place piece at back/bottom/right comes to the top face making a temporary triangle. Apply the Corner Piece Series and then turn the white face  $90^\circ$  counterclockwise.

The yellow/red/blue piece at front/top/left in Fig. 12a will move along the front/top edge and into place at front/top/right. The green/red/blue piece has the most difficult situation you will find in trying to place two corner pieces at the same time. This is indicated by the checkerboard appearance it makes with the red/blue edge piece next to it. This corner piece belongs at back/top/right and its green face must be in the green face of the cube.

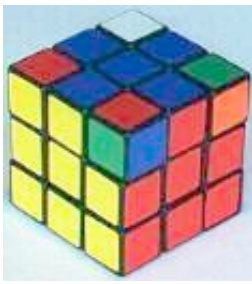


Fig. 12a

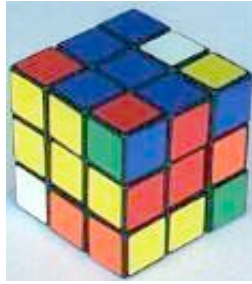


Fig. 12b

It will replace the blue/green/orange corner piece which now has its blue face in the green face of the cube. This means we must find (create) a Corner Piece Series in which the green face of the green/red/blue piece replaces the blue face of the blue/orange/green piece. Turn the green face  $90^\circ$  counterclockwise; turn the white (bottom) face  $90^\circ$  clockwise; and turn the green face  $90^\circ$  counterclockwise. We have the cube in Fig. 12b. As required, the blue face we are looking for is on the top face at back/top/left.

Apply a Corner Piece Series moving corner pieces about the triangle: front/top/left; front/top/right; back/top/left. Now reverse the preliminary turns (green face  $90^\circ$  clockwise; white face  $90^\circ$  counterclockwise; green face  $90^\circ$  clockwise). Again, two corner pieces have been moved into place at the same time.

The cube in Fig. 13 shows an unusual arrangement. The pieces making a checkerboard pattern on opposite sides of the red/yellow edge piece need to be exchanged as do the pieces across the diagonal on the white face. We could put one of the first pair in place using the preliminary three turn sequence described in the previous paragraph. Or we could put one of the latter pair in place using a two turn sequence. We will do the latter simply because it is shorter.

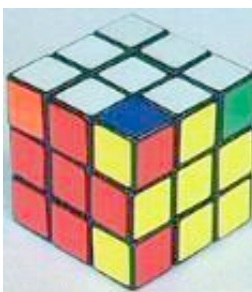


Fig. 13

Move the green/red/white corner piece so that it is across the cube diagonal (not a face diagonal) from its proper position (turn the orange face  $90^\circ$  counterclockwise). Next turn the blue (bottom) face  $90^\circ$  counterclockwise. Note that this turn is at right angles to the first turn. Now the green/red/white corner piece is diagonally across the red face from its proper position and can be moved into position and orientation with the proper Corner Piece Series.

If the second turn in the paragraph above had been  $180^\circ$  instead of  $90^\circ$  then the green/red/white piece could have been moved into place along a cube edge (the green/red edge) with the proper Corner Piece Series.

When five corner pieces have been placed Step Four will be completed. If you can place two corner pieces at a time obviously the total number of applications of the Corner Piece Series will be reduced. However, anytime you find a piece in place but with the wrong orientation you will have to remove it. You can do this at the same time that you move another corner piece into place but you can't place two pieces while removing a third. And anytime you find two corner pieces are each located in the other's proper place you will be able to place only one corner piece while moving the other out of the way.

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## STEP FIVE: THE END GAME

With only three corner pieces remaining out of position all must be involved in the final Corner Piece Series. Further, each must move simultaneously into its correct position and with the right orientation.

It is possible that the three target corner pieces are on the same face and will move into place via a Corner Piece Series without any preliminary moves. But that would be rare indeed. We won't even think of it. Rather, the first thing for you to do is to look for a corner piece which can move along a cube edge into its correct position while rolling over into its correct orientation. Surprising as it may seem, in about half of all instances you will find that such a piece exists. About one-fourth of the time you will even find two such pieces.

The corner piece at back/top/right in Fig. 14a is just such a piece. (Its color on the back side of the cube is blue.) The proper Corner Piece Series will cause it to move along the top/right edge to the front/top/right corner of the cube where it will be in the correct position/orientation. There are two different cube faces which may be used as the front face in the Corner Piece Series and two different triangles about which the corner pieces may move.

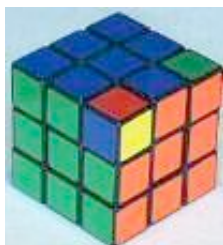


Fig. 14a

In one such case, the blue/red/yellow piece at front/top/right will move to the back/top/left corner (i.e. the yellow/blue/red corner) with its yellow face on top of the cube. In that series, the green face is front and the first move is a rotation of the blue (top) face to the left.

In the other case, the front face is red (the left side in Fig. 14a) and the first turn is again a rotation of the blue (top) face to the left. In this case the blue/red/yellow piece will move to the corner now occupied by the blue/green/red corner piece. Again the yellow face of the blue/red/yellow corner piece will come to the top of the cube.

You should note that the first two corner pieces will be on the same face and will be adjacent to each other. The first will go into position/orientation replacing the second. The second will go to either of the two remaining corners on the top face with the color which is on the right side of the cube at the start of the Corner Piece Series coming to the top. We will refer to the third and fourth corners as the "target positions".

Naturally the second corner piece must replace the third corner piece with the third

replacing the first. But where is the third corner piece? A little thought should convince you that, in this case, the third piece is somewhere in the yellow face of the cube. Fig. 14b (the entire cube in Fig. 14a has been rotated 90° clockwise on an axis from top to bottom) shows that the third corner piece is in the yellow/blue/red corner. It should be clear that if the yellow face of the second corner piece replaces the orange face of the third corner piece (the face which is in the yellow face of the cube) the second piece would be in the right position and have the right orientation.

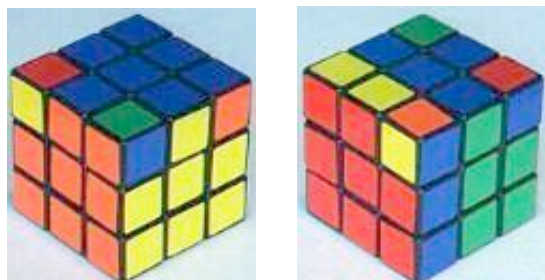


Fig. 14b

Fig. 14c

How can we make that happen? We must bring that orange face to the top (blue) face of the cube in one of the target positions. This can be done with a 90° clockwise rotation of the red face as shown in Fig. 14c. Then, with red as the front face, a Corner Piece Series beginning with a turn of the blue face to the left will cause these three corner pieces to move clockwise about the front/top/right; back/top/left; back/top/right triangle.

The yellow face of the yellow/red/blue corner piece replaces the orange face of the orange/blue/yellow corner piece and when the red face is rotated 90° counterclockwise (the preliminary turn is reversed) each of the corner pieces will be in its correct position and orientation.

But, you might say,..."You made sure that each of the first two pieces went to the right place but you did nothing about the third". You don't have to worry about the third corner piece for, when all other pieces on the cube have been properly placed, the last piece must be in position and must be properly oriented as well. It is physically impossible for it to be otherwise. Thus you must ensure that the first two pieces are correctly placed and the third one will take care of itself.

As indicated above, when you reach the End Game, half the time at least one of the corner pieces will be in position such that a Corner Piece Series will cause it to move along a cube edge and into position/orientation. If you don't find such a corner piece you must create one. About 70% of the time you will do so with a single 90° rotation of a cube face. And about 30% of the time you will do so with a 180° rotation of a cube face.

The cube in Fig. 15a does not have a corner piece which can be moved along a cube edge and into place. But the red/white/yellow corner piece is diagonally across the yellow face from the corner where it belongs. It could be made part of a triangle which



would send it across the diagonal to its proper place. A corner piece in such a position may be moved to an adjacent corner so as to create a corner piece which can be moved along a cube edge and into place. You can do this with a  $90^\circ$  rotation of either vertical face in which the corner piece is located. For example, the orange face could be rotated  $90^\circ$  clockwise. Fig. 15b shows the resulting cube with white as the front face.

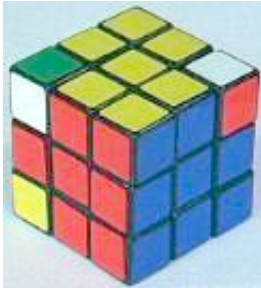


Fig. 15a

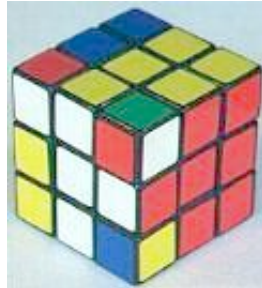


Fig. 15b



Fig. 16

The cube in Fig. 16 does not have an appropriate corner piece adjacent to its correct position. Neither does it have a corner piece which could be moved across a face diagonal to its proper place. But it does have a corner piece which can be rotated  $180^\circ$  and be in a position from which it can move along a cube face and into proper position/orientation. That corner piece in Fig. 16 is the green/red/white piece in the back/top/left corner of the cube (all you can see is the green face).

You can turn either of the faces, which (of the three remaining out-of-position corner pieces) contain only the green/red/white corner piece, by  $180^\circ$  and that piece will be in position such that the proper Corner Piece Series will move it along a cube edge and into place. Turning the third face of the cube (yellow in this case) will not work.

With this understanding we can construct the rules for successfully completing the End Game:

1. Find a corner piece which may be moved along a cube edge and into place. If none can be found create one.
2. Note the face color (of the second corner piece) which will come to the top face of the cube in a target position during a Corner Piece Series.
3. Locate the third corner piece in the cube face of this same color and note the color of the third corner piece face which is in that cube face.
4. Bring the third corner piece to the top of the cube, by various face turns, such that that color is in the top face of the cube.
5. Perform the Corner Piece Series so that the target color of the second corner piece replaces this color (named in 4 above).
6. Reverse the preliminary face turns indicated in 4 above.

This process is much easier to carry out than it is to describe. Several examples will be given below.

The white/yellow/orange corner piece at front/right/top of the cube in Fig. 17a may be moved along the white/yellow edge and into place. It will replace the red/green/blue piece. The latter will move to either of the target positions with its blue face coming to the top. We examine the blue face of the cube and find the yellow face of the white/red/yellow corner piece in that blue face. Hence we need to get the yellow face of the third corner piece into one of the two target positions. This is done by a  $180^\circ$  rotation of the green face giving the cube in Fig. 17b (the entire cube has been rotated  $180^\circ$  so you can see all three faces of the third corner piece).

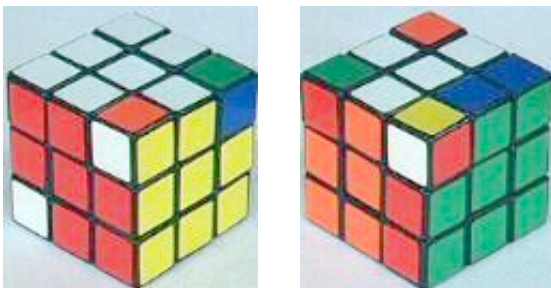


Fig. 17a

Fig. 17b

Now hold the cube with the green face in front and begin the Corner Piece Series with a turn of the top (white) face to the right. The third corner piece goes across the diagonal of the white face (with its white face coming to the top) and into its proper position and orientation.

You do not always have to examine the face of the cube which has the target color. When the white/yellow/red piece in Fig. 18a moves along the white/yellow edge of the cube the green face of the second corner piece comes to the top in either of the target positions. We need to move the face of the piece at the lower left of the cube which is now in the green face (we see only its white face) into one of the target positions.

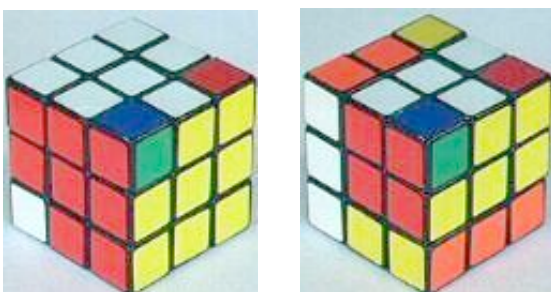


Fig. 18a

Fig. 18b

Rotate the bottom face by  $90^\circ$  counterclockwise and then the left face  $90^\circ$  clockwise. This gives Fig. 18b. The face we were looking for is yellow (we would have seen that if

we had turned the cube to reveal the green face). The first turn of the top face is a rotation to the top left. When the series is completed reverse the original two turns and the cube is complete.

The corner piece at back/top/left in Fig. 19a will move along the top/left edge of the cube and into place. The green face of the white/orange/green corner piece will come to the top in a target position. The yellow face of the third corner piece is in the green face of the cube. We can bring that yellow face to a target position by the three turn sequence we learned in Step Four. It is: green counterclockwise; blue (bottom) clockwise; and green counterclockwise.



Fig. 19a



Fig. 19b

There is the yellow color on the top face in the back/right corner of the cube (Fig. 19b). Apply the Corner Piece Series and reverse the three preliminary turns. The cube is restored.

The cube in Fig. 20a has two corner pieces which can move along a cube edge and into position. We could use either one of them as the first corner piece. Note that all three of the final corner pieces have an orange face and, in each case it is in the orange face of the cube.



Fig. 20a



Fig. 20b

We will use the yellow/white/orange piece as the first corner piece. Let us turn the entire cube 90° clockwise on an axis from top to bottom. Now turn the bottom (green) face 90° clockwise and then the red face also 90° clockwise. This gives the cube in Fig. 20b. (Again we chose this view so you could see all three faces of the third corner piece.) With red as front, turn the top face to the right and complete the Corner Piece Series. Reverse the two preliminary turns and the cube will be done.

In Fig. 21a none of the pieces is adjacent to any other. As a general rule this should be

avoided but it is not much of a problem in this case because any one of the three corner pieces could be turned  $90^\circ$  and thereby create a corner piece which could be moved along a cube edge and into its proper place. For example, turn the orange face  $90^\circ$  counterclockwise (Fig. 21b shows the result except that the entire cube is turned clockwise in order to show all three faces of the green/white/red corner piece) or turn the red face  $90^\circ$  clockwise.



Fig. 21a



Fig. 21b

But if the orientation of each were to be changed so as to put a corner piece face into the cube face of the same color then things would change drastically.

(For example, the yellow color of the red/blue/yellow piece is moved to the yellow face of the cube at front/top/left, the red face of red/white/green is moved to the red face of the cube and the white face of orange/white/yellow is moved to the white face of the cube.) Although this arrangement is rare, it is the most difficult you will encounter.

I will leave this for you to solve for yourself. But I'll give you a hint. You will have to move one of the corner pieces in two different directions.

If you have one of those cubes with symbols on four of the faces then go to [Rubik's 4th Dimension Cube](#).

**If you are having trouble following this description you may be interested in a little help. A videotape is available showing a 53 minute description of this solution. Or you may simply wish to give the videotape to someone else.**

[video](#)

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